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THE SIMONDS' UNIVERSAL METAL ROLLING MACHINE.

BY GEORGE F. SIMONDS, Fitchburg, Mass.

[*Read at the Stated Meeting of the* FRANKLIN INSTITUTE, *Wednesday, June 20th, 1888.*]

JOS. M. WILSON, President, in the chair.

MR. PRESIDENT, MEMBERS OF THE INSTITUTE, LADIES AND GENTLEMEN:

The invention which I have the honor to explain to you, is the result of incident, of mistake, of reasoning, of experimenting. From a small germ, it has shown a steady and substantial growth. Difficulties have been encountered, but almost invariably the removal of a difficulty has developed some new and unexpected advantage. It has spread out and covered fields, broader than we dreamed of two years ago, until there seems to be no limit to its capabilities. It is the natural way to make an endless variety of articles, in the saving of manual toil, in the improving

of the quality of the articles produced, and in opening new opportunities for the employment and convenience of mankind. That it has reached perfection in all its details is not claimed. Far from it! for the possibilities of an invention covering so much ground could hardly be exhausted in the short space of four years, but the underlying principles are established, and it can safely be declared a success.

In January, 1884, while journeying from home, my attention was incidentally called to the possibility of forging round metal articles, like articles ordinarily made in a turning lathe, between oppositely moving surfaces. As has always been my custom when a new idea presented itself, I made a sketch of a device for practically carrying it into effect, and wrote a description of the same. On my return an experiment was made with putty as a material between two tapering shingles, grooved to form a ball, and with sufficient success to convince me that it could be developed to substantial results.

I wrote to my solicitor in Washington, explaining and describing what had been done, and asked him to make an examination in the Patent Office and report to me what had previously been attempted in that line. In due time he reported that he had made a careful preliminary examination of the records of the Patent Office, that there was nothing there of the character referred to, and that I had the field to myself. I was much surprised at this report, as it seemed very strange that so simple a principle had not been tried before, but, acting under the information received, I built a machine.

I had in my employ a young and intelligent mechanical engineer who made my drawings, superintended the construction of the machine, and tested it. After some weeks of persistent experimenting he reported to me, that, in his opinion, the thing was a failure and we must give it up. I told him to cover up the machine, and we would let it rest. Up to this time my dies had been constructed on inclined planes, approaching each other as the dies were moved forward, like the illustrations shown in *Figs.* 1 and 2. After a few days, I told him to make the drawings and construct dies to make a miniature car axle, in which the forming or shaping surfaces of the two dies should run parallel to each other, and the reducing and spreading surfaces diagonal to the

forming surfaces, and also at an angle to said forming surfaces and to each other, and said reducing and spreading surfaces to be provided with corrugations to force and control the rotation of

FIG. 1.

FIG. 2.

the blank being worked upon. These dies are illustrated, as shown in *Figs.* 3, 4, 5, 6, 7, and this was the germ from from which the success of the invention developed. In addition to the small

FIG. 3.

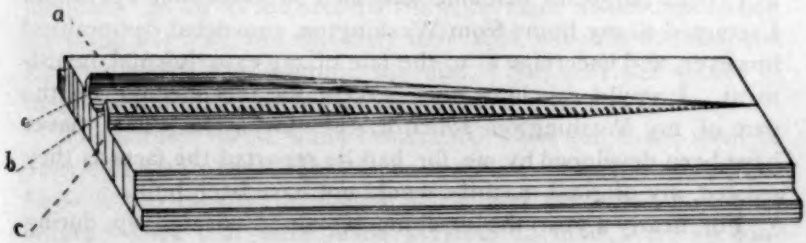


FIG. 4.

miniature car axles, which were then produced, I made dies for rolling balls and small projectiles, and applied for patents.

In June, 1884, I learned that the Patent Office work was much in arrears and that my application would get no hearing for six

months in the regular course. Through the courtesy of the Secretary of War, on account of the adaptability of the machine for war purposes, my cases were made "Special" and got immediate hearing. Much to my surprise I was confronted with a

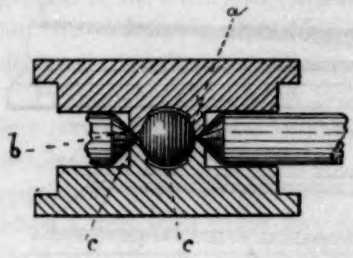


FIG. 5.

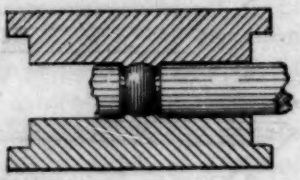


FIG. 6.

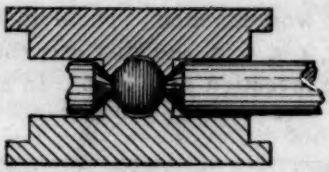


FIG. 7.

multitude of patents, and learned that many before me had attempted to accomplish results in the same direction, but so far as I could judge no machine was then in successful operation. I returned to my home from Washington, somewhat demoralized however, and uncertain as to the fate of my experimental investment. I would say here, that, except for this mistake on the part of my Washington solicitor, this invention would never have been developed by me, for, had he reported the facts as they existed, my original machine would not have been built.

For nearly a year the machine remained covered up, during which time it became apparent that no other person had ever accomplished what I had done, and after a personal investigation in many places in this and other countries, with the best of counsel, and with all the reference patents that could be found before us, we set to work to ascertain what I had done that they had not, that I should have gotten a result which they did not

attain. As a result of that investigation, my patents of June 9th, 1885, were issued to me.

Up to the time of the issuing of my original patents, I had made but one experimental machine. I immediately constructed what is termed a horizontal 6-inch and a 12-inch machine, and in November of the same year took two 6-inch machines and one 12-inch machine to London, England, set them in operation, secured an order from the English Government for a half million of Nordenfelt steel projectiles, and in February returned to America, having formed a company which owns the patents and is operating the machines in that and other European countries. The facilities and force of workmen in Fitchburg were at once increased, and developments continued in various directions until November, 1886, at which time a company was formed in the City of Boston, and substantial developing works were erected in the City of Fitchburg. In the summer of 1886 machines were made with dies running vertically with a marked success over the horizontal form of construction, and all machines for practical working are at present built on that principle.

(Illustrations of the first original machine, and of the machine of latest design were here shown on the screen.)

It is a somewhat remarkable fact, that among all those who had applied for patents on devices of this character, the man who came nearest success previous to the construction of this machine, made his experiments more than eighty years before mine commenced. So far as the records show, he made no attempt to roll anything but lead, and this only into balls, which is the simplest form on which the machine operates. But, with the softest of metals and on the simplest of forms, his dies were a failure.

The hardest metal, when heated, will yield and shape itself to your will with perfect ease, if you handle it right, but attempt to force it too rapidly, or against itself, and the result is a total failure. Dies that were made previous to mine, were so constructed as to attempt to force the metal into shape by direct pressure toward the axis of the bar. Again, no attempt was made to control the rotation of the blank to the required velocity, or to prevent the twisting of the blank or article between the dies, conditions absolutely essential to a successful prosecution of the work: to express it differently, the method of manufacture

under this principle was not discovered till my dies were originated.

If two platens with plane surfaces placed at a given distance apart, with their surfaces parallel, are moved in opposite directions, a round bar, with a diameter equal to the distance between the surfaces placed between them with its axis at right angles with the line of movement of the plates, will be rotated, without moving in the direction of either of the platens. If the diameters of the bar be somewhat greater than the distance between the platens, and if it be of plastic material, it is obvious that if it is introduced between the platens and rotated, its diameter must be reduced and its length increased. This is the fundamental conception which underlies what I have done and what others have attempted. If on the face of each of the platens, a narrow tapering rib be formed running in the direction of the line of motion, the rib of one platen being directly opposite that of the other, it can be easily seen that the movement of the platens will form a groove around the bar corresponding in cross-section with a cross-section of the ribs. It can also be seen that the metal at the bottom of the grooves formed by the ribs will be nearer the axis of the bar than the metal in contact with the plane surfaces of the platens. If the rate of rotation of the bar is determined by its contact with the surfaces of the platens, the rate of motion of the metal at the bottom of the grooves will be less than that of the surface of the ribs, and the ribs must slide over the surface of the bottom of the grooves. On the contrary, if the rate of rotation of the bar is determined by the contact of the metal at the bottom of the groove with the faces of the ribs, the metal in contact with the general surface of the platens will move faster than the dies. These facts present the first difficulties which arise in the attempt to make the fundamental idea available for practical purposes.

Again, it is easily seen that if two or more ribs are formed on each platen, their engagement with the metal of the bar will interfere with and restrain the axial elongation of the bar, which is indispensable to its reduction in diameter. This fact presents the second difficulty which is met and must be provided for, in forming round articles of varying diameters.

Again, if the rotation of the bar is secured only by the friction

of its working surface it is liable to fail, especially where the portions of the bar in contact with the dies are of different diameters. I think that all persons who, before myself, have endeavored to solve the problem of rolling round articles of varying diameters have failed to provide for these difficulties and conditions.

In my dies the portions which perform the work of shaping the article are raised above the general surface of the platens. These raised portions commence at a point and extend in two directions diagonally across the platen, or at an angle with its line of motion. The shaping of the bar commences at a point where the dies first come in contact with the bar, and proceeds spirally in both directions to the ends of the article.

The raised surface of the diverging ribs which form the die proper and which press directly toward the axis of the bar, or to the corresponding part of the opposite die, gives the required form to the article. I call this the forming or shaping surface (see letter *a*.) The outer surfaces of these ribs are formed at an angle of from ten to forty degrees with the axis of the bar, and by virtue of this inclined surface and of its diagonal position across the platen, an axial strain is brought upon the metal in contact with it, and the surplus metal is forced toward the ends of the article. I call this inclined surface the reducing and spreading surface (see letter *b*). This spreading surface is provided with teeth which engage with the metal and insure its rotation, and as the engagement is close to the portion of the rib or die which is acting on the metal, it gives the same rate of motion to the metal at that point that the die itself has. I thus ensure the efficient engagement of the metal with the die; the removal of the surplus metal axially; and the same rate of motion of the metal at the parts being acted upon, that the dies have.

It will be observed that these dies commence their operation by reducing the blank at any given desired point to the finished size of the article at that point, and spread the surplus metal axially, making and finishing the shape as the work progresses. The reducing and spreading surfaces remove the surplus metal outwardly, while the final finishing to accurate size and shape, and the obliterating of the marks caused by the rotating teeth is done on the forming or shaping surfaces near the junction of

those surfaces with the reducing and spreading surfaces. Or, in other words, the principal part of the work is done *outside* of the shape of the article and finished *inside* of the shape of the article. It will also be noticed that the rotation is forced and controlled outside of the shape of the article, or on the blank, instead of on the surface of the article. You will also see that by removing the surface of the die in places, or cutting it away where no work is being performed (see letter *c*), I take away all unnecessary friction between the blank or article and the dies, which leaves the rotating teeth free to force and control the rotation of the blank. By the construction of these teeth the velocity of the rotation of the blank at any given point may be increased or retarded when desirable. The fact that the rotation can be controlled on a given diameter makes the rolling of irregular shapes possible.

One of the earliest and most serious difficulties that presented itself in the practical working of the machine, was occasioned by the dies slipping on the blank that was being rolled. The first experimental dies were constructed of cast-iron, and the corrugations, or teeth, to control the rotation of the work, and prevent the slipping, were formed by cutting transverse grooves on the reducing and spreading surfaces with a round-nose chisel. On the first dies made of steel, the teeth were formed with a chisel, as a file cutter cuts a file. Later on, knurls were introduced for forming the teeth, which method is now employed, and which is entirely satisfactory. The dies, as you will observe by illustration in *Fig.* 3, are made on a cast-iron bed, planed to fit into the platens on the machine, and their faces are provided with dovetail diverging recesses, which receive and retain the steel working surfaces of the dies. These steel surfaces are made in sections, so that they may be hardened and tempered with facility, and nicely fitted to the bed. To give the proper form to the dies, a templet is made conforming to one-half a section of an article to be produced, and the forming and shaping surfaces on the dies, are then planed with that templet to conform to a section of one-half of the article. The dies are then placed diagonal to the bed of the planer, and, with a square-faced tool, the reducing and spreading surfaces are planed diagonal to the forming surfaces, commencing at the starting point on the die, and extending to the finishing end of the die. The question of angles is important in

the construction of these dies, the horizontal angles varying from 8 degrees to 20 degrees, and the vertical angles from 10 degrees to 45 degrees.

In the practical working of the machine, the bar from which the article is to be produced is heated at one end, the heated portion placed between the dies, and, as the dies move simultaneously in opposite directions, the bar is rotated on its axis between them, and the proper form or shape given to the article during one passage of the dies. The dies are then returned to position, and the operation repeated to make another article.

In the production of any article, other than a plain cylinder, as the dies must of necessity move with equal velocity, there must be a slipping of some part, or parts, of the article on the dies, or a twisting of the article, unless some provision is made to avoid it, and the twisting of the article is very objectionable, as will hereinafter be described. The system of cutting away the dies where the work is not being performed, to a great extent removes this difficulty, and this is an important feature in the successful working of this process. Other features have been introduced to avoid this trouble, which it is not necessary for me to herein enumerate. One of the difficulties encountered, and which at one time seemed serious, was a tendency of the work to come out of round and to show a seam, or a hole through the centre, or, as some would express it, become piped. Any one who has had an extended experience in working iron or steel under a trip-hammer, has encountered this difficulty with inferior qualities of steel and iron. I have discovered that one cause of this condition of things with this machine, is the twisting of the stock between the dies, and if the twisting is avoided the difficulty is largely avoided. Another cause is rolling the bar under pressure after the necessary work is done. If a round bar of iron or steel is rolled between two flat surfaces, with a gradual increased pressure, it will assume a three-cornered shape, or, in other words, more metal will rotate between two plates in a three-cornered than in a round form, and there will be a tendency to shatter the centre of the bar, and a slight seam, or hole, will appear, extending through that part of the bar so acted upon. I have recently made changes in the dies for preventing the articles coming out of round, which is effectual.

In the earlier experiments one uniform grade of high-priced steel was used, for the reason that there could be gotten in the market, any size of this steel and in any quantity, and an attempt to work different varieties of steel would introduce needless complications and delay. When the experiments were transferred to the low-priced, open-hearth, and Bessemer steel, this tendency of the work coming out of round, and with a hollow centre, was more apparent than with the crucible steel, but in the construction of the dies having avoided the difficulty of the work coming out of round, the soundness of the product depends, as in other methods of forging, on the strength and homogeneousness of the steel. We are buying in the open market open-hearth steel, not made expressly for us, from which we are producing a great variety of articles that are without exception satisfactory to purchasers and users, in fact, I think, in every instance, since the correct principle of the construction of the dies was discovered, every article produced has been pronounced superior to those made by the old processes.

From the samples which you see before you, you will notice that we have succeeded in rolling many kinds of irregular shapes like ovals, squares, hexagons, pinions, etc. You will also observe that articles have been threaded with satisfactory results, and during the same operation in which the blank is rolled to shape. In fact, all the underlying principles necessary to a complete success of the process have been fully established, and the problems before us relate principally to the production of accurate and uniform work. By the present methods in the manufacture of many of the articles which this machine produces, after the article is forged to approximate shape and size, the surplus metal is necessarily cut away, to bring it to the finish size, by means of cutting tools. The lack of uniformity by those methods is largely due to the give or spring of the machine, and the wear of the tools in use. By this present method the machine can be constructed with great rigidity, and there is no perceptible wear on the dies to change the form or size of the work. During the past year we have rolled 8,000,000 boot calks, the little pointed tool steel articles, which you see on the case before you. Our dies have not been worked under as good and favorable conditions as we can even now use them, but we can roll, as an aver-

age, 100,000 forgings without removing the dies from the machine, while the surface of the dies is not then materially worn away. After rolling, as an average 100,000 forgings, we find it desirable to renew the rotating teeth, and to do this we anneal the steel portion of the dies, plane their surfaces, taking off a slight chip, temper them, and they are again ready for use. In this way, with one set of steels in a die, we have rolled 600,000 forgings. The dies will invariably produce a reverse *fac simile* of themselves, and under the right conditions the articles will be exact duplicates of each other. Those conditions consist simply in a uniform metal that is being worked, and a uniform heating of that metal. We have reason to believe that we can bring those conditions within such narrow limits as to compete in uniformity in the manufacture of such articles as the machine will produce, with the results as now attained by existing methods. One of the advantages of this system of manufacturing is, we can use steel of high or medium temper, as well as the softest steel or iron. In consequence of this we start with a material that is stronger than is now generally used. Again, it is a well-established fact that a forged steel article which retains the skin surface has a greater tensile strength, will stand a heavier breaking weight, possesses superior wearing qualities, and when used as a projectile will endure a more powerful impact strain to what it does when that surface is removed. These two facts insure a great advantage in the quality of goods produced.

Experiments have demonstrated that we can roll from the square, hexagon, or octagon bar with equal facility as from the round bar; this enables us to roll from what is known among metal workers as the billet, and produce any shape, round, square, hexagon, oval, tapering, threaded, or otherwise, introducing all the various shapes into the same die and with a uniform result; in this way the whole system under which a great variety of goods are produced can be changed to advantage. Many articles are at present made from a finished bar smaller than some portion of the article, and the larger portion is formed by upsetting; this has a tendency to shatter the fibre of the metal and otherwise weaken it by forming cold shuts. We start from a billet larger than the largest portion of the article to be produced, and shape the whole at one operation; or, in other words, avoid the neces-

sity of using a finished bar from which to make our product, thus saving the expense of one operation in the manufacture of the raw material.

An important advantage by this method of forging is the saving in the power required over the use of hammers, drops, or hydraulic presses. The work is done principally on inclined planes, and there is a continuous and subtantially a uniform amount of work from the time the operation is commenced until it is finished, and under the most favorable conditions as regards power, and wear and tear of machines.

Several tests of the quality of the products of the machines have been made, and I will cite two as illustration: The Nordenfelt projectile ordered by the English government are three inches long by one inch in diameter. They were required to vary not over one thirty-second of an inch in length, and less than five one-thousandth in diameter from a given size at three points, and also to be to an exact taper; the machine rolled them within these limitations. Ten shots were fired by the English officers at the testing grounds at Woolrich in the presence of Commander Folger, of the U. S. Navy, and myself. The range was one hundred yards, and they were fired through a one-half inch steel armor plate and against a like plate placed fifteen inches in the rear of, and at an angle of forty-five degrees to the first plate. After this remarkably severe experience they were so little distorted as to stand the gauge tests. The officers in charge pronounced them the best shot that ever went through their guns. The Government was at that time manufacturing these projectiles at Woolwich, they discontinued the manufacture and gave the order referred to.

In April last past, and within a week after the first die was made to roll a fish-bar bolt, ten bolts were submitted to and tested by the Pennsylvania Railroad Company in comparison with five of their standard bolts as now in use. They were pronounced satisfactory in workmanship, and stood a tensile strain of an average of thirty per cent. more than the standard.

Previous to the construction of this machine, hardened steel balls, accurate to size, were unknown. To-day we are furnishing them in any quantity and of any size up to two inches in diameter, that vary less than one-thousandth of an inch in size, and

can manufacture to six inches or even larger if required. The Lick telescope revolves on hardened steel balls one inch in diameter, rolled with this machine. Balls two inches in diameter of great accuracy and precision have been supplied to a famous scientist with which he accomplishes results heretofore impossible.

Four propositions seem to have been fully established pertaining to this invention:

First: Any article that comes within the range of the machine can be made at a less cost than as now produced.

Second: Everything that the machine makes can be turned out superior in quality to the same article as now manufactured.

Third: Experiments have demonstrated that large articles are rolled with the same facility as those that are small in size.

Fourth: There is no conceivable limit to the variety of work that it is capable of producing.

As a comprehensive illustration of the possibilities of this process I may mention, that a coach axle can be rolled from the billet, complete at one pass of the dies, giving all the forms and shapes required, viz.: round, hexagon, square, the collars, the journals, the threads for the nuts, and cut to length, and in less than thirty seconds of time.

[Referring to the illustrations, Plates I., II., and III., Fig. 8 is an illustration of the first machine made with the dies arranged to move horizontally. Fig. 9 is a front sectional view of the same, showing dies for rolling a small car axle; and Fig. 10 an end vertical section. Fig. 11 is a general view of the machine, of a later design, with the dies in a vertical position; while Fig. 12 gives a front elevation of the same. Fig. 13 an end view and vertical section, and Fig. 14 a plan view.]

THE ELECTRICAL DISTRIBUTION OF TIME.

By ALLAN D. BROWN, Commander, U. S. Navy, Assistant Superintendent of the Naval Observatory, Washington.

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *January, 13, 1888.*]

Concluded from Vol. CXXV., page 474.

From the General Post-Office the time is distributed in the city of London hourly and throughout the country at 10 A. M. and 1 P. M.; the arrangement for this distribution is very elaborate, there being four groups of circuits, each worked by a separate relay, which is itself worked by the hourly signal from the observatory. The lines within the city being used for time purposes only are always in circuit; the country lines, however, are used for ordinary commercial purposes; hence it is necessary that they should be cut out just before the times at which the signal is to be transmitted; this is accomplished automatically by a specially-constructed clock which opens the relays about two minutes before the hours of 10 and 1, thus clearing the lines for the reception of the signal; about ten seconds after its passage the relays are closed by the action of the clock. It will be observed that the signal sent over the wires is but a single beat, and is, therefore, of a character that would hardly be suitable for use in this country of magnificent distances. All of the time service work outside the observatory (except that of the Deal ball) is under the supervision of the Post-Office Department, and a large number of persons are thus supplied with the Greenwich time direct; in many cases the signal is repeated by local operators to smaller offices, so that, practically speaking, the standard time of the country is dispersed throughout England, Scotland and Wales; in Ireland, Dublin time is the standard, and Greenwich time is used only for purposes of comparison.

In addition to the time ball at Deal, a like ball is dropped daily at the same hour (1 P. M.) from one of the turrets of the observatory; this ball is the oldest in existence, having been first dropped

in 1833. Time guns are fired by the same signal at Newcastle and North Shields.

Reference has been made to the distribution of time by private parties in the city of London; this is done by the firm of Barraud and Lund, whose system is one of much ingenuity. In it ordinary clocks are provided with an attachment by which the error of the clock can be corrected at any exact hour, provided that this error does not exceed two minutes. In the central office is a mean time regulator provided with means for correction of its error by an electrical attachment similar to that in use at the observatory in Greenwich; the error of the standard is ascertained by a comparison of the signal received from the observatory at each hour, with the beats of the regulator which are registered upon a chronograph. The regulator is corrected when necessary and sends automatically a signal over all the lines leading from the office at 0 minutes and 0 seconds of each hour. This signal actuates the armature of an electro-magnet in each clock; from this armature are projecting arms which make a sliding connection with the setting pins which protrude through a slot in the dial, and act like a thumb and finger to bring the minute hand to the 0 position; the arms have a counterpoise which serves to bring them back to their normal position when the current ceases; the contact in the regulator clock is not instantaneous, but prolonged for some seconds in order to be sure of effecting the desired correction. Combined with these synchronizing clocks are audible and visual signals, the first being made by a bell, the second by a revolving disc which shows alternately red and white; such a signal is used in the London Stock Exchange; but it would seem to have the disadvantage of requiring that attention should be directed to it for some time before its arrival.

In Liverpool, Glasgow and Edinburgh the Greenwich time is distributed by several clocks provided with the Jones system of regulation; at least this was the case up to a comparatively recent date.

In Paris, the observatory distributes the time to thirteen so-called horary centres, each of which is furnished with a secondary clock that is in itself a good and expensive timekeeper, and is regulated by the central clock through a modification of the Jones system. The central standard, besides being provided with the most approved

compensation, has also upon the pendulum a small box in which light weights are from time to time placed or from which they are removed to restore the rate of the clock to the normal when it is found to have been disturbed. At each vibration of the pendulum the circuit is closed for a large fraction of a second and the current from the battery switched in; this animates an electro-magnet situated beneath the centre of the arc of vibration, so that a piece of soft iron carried by the pendulum bob is attracted, and thus the clock (which is kept running on a gaining rate) is retarded; the adjustment is made so that the amount of retardation is just sufficient to keep the secondary clocks beating in unison with the primary. The secondary clocks send hourly signals automatically to various places in their immediate vicinity, thus distributing the time over a large area. I am informed, however, by a gentleman who has recently been in Paris and examined the subject, that this system is one that is not now depended on.

In various cities of the continent the system of Hipp is used quite extensively; in this system a central- or master-clock drives a number of secondary ones, very much after the system used at Greenwich. In Berlin there are a few clocks regulated on the Jones system, but there cannot be said to be what is regarded as an efficient time service.

Some idea of the extent of the distribution of time from observatories in this country may be gathered from the statement that there are over 124,000 miles of railway thus supplied; of this number, the Naval Observatory at Washington supplies 29,000 miles; that at Allegheny, Pa., 24,000 miles; that of the Washington University at St. Louis, Mo., 22,000 miles; being a total of 75,000 miles; the remaining 49,000 are supplied by nineteen other observatories, two of which are in Canada.

The system used by all, except the Naval Observatory, is what may be called a continuous one; that is to say, the standard mean time clock records its beats—with certain omissions—upon various sounders connected with it. In some of these clocks the contact wheel on the seconds arbor is so cut as to send the signal every second, omitting certain seconds at the close of the minute, the beat following this pause marking the beginning of each successive minute; in others, only the even seconds are transmitted, with a similar arrangement for determining the beginning of each minute;

some have every fifth minute noted by an omission of a different character, and in others a like omission marks the termination of the hour. It is evident that there is no way in which to mark any particular minute; in the fifth minute system the time can be identified by a distant receiver, provided he knows what fifth minute is being signalled—in other words, if he is sure of his time within two and one-half minutes; in the hourly system there will be evidently no trouble in recognizing the hour at its termination. As a rule, these observatories are connected by wire with the establishments of various jewelers and watchmakers in the imme diate vicinity, as well as with the telegraph wires leading out of the city. At a certain prescribed hour—generally just before noon—the operator in the telegraph office switches his wires into connection with those from the observatory, and the beats of the standard clock are thus transmitted over a greater or less extent of country; the time thus received is used primarily by the railways, and secondarily by the jewelers and others in the towns through which the lines pass; in some instances these have sounders in their own offices; this is especially the case in the larger cities. In smaller towns, the signal is taken off the sounder in the office by comparison with a watch, which is itself afterward used as a means of comparing the regulator and thus ascertaining the error of the latter.

Generally speaking, the time received by the railways is only at their division headquarters, and later it is transmitted over each division wire by hand, the clock in the office being taken as the standard. The uniform train rules of the railroads now prescribe that the hours for the distribution of time shall be 5 P. M. Eastern time, or 4 P. M. Central time.

The system adopted by the Naval Observatory at Washington is like that at Greenwich, in that signals are sent only at a certain prescribed time, viz., at noon of the seventy-fifth meridian. The practice at Greenwich of altering the standard clock, and sending its beats over the wires, is not, however, that used in Washington; there the standard clock is allowed to run on and accumulate its error without interference, a separate clock, called the transmitter, being used for the purpose of sending the time signals. This clock is compared at 11.40 A. M. daily with the standard, which has itself been compared with the standard sidereal clock at 9

A. M., as well on the evening before, if observations have been made. If an inspection of the barometric and thermometric records shows no large fluctuations, it is assumed that the rate of the clocks has been constant; if such changes are noticed, however, allowance is made for them by the observer, in accordance with his judgment, derived from previous experience. This is, in effect, the same thing as is done at those observatories where the standard clock is used, only there this clock is altered by the use of weights upon the pendulum, while with us the error of the transmitter is ascertained, and then the latter is set to the correct time. Being thus set as nearly as possible—and this can be done to within the twentieth of a second by means of the chronograph—at three and one-fourth minutes before noon the clock is switched into the circuits leading from the observatory to the offices of the Western Union Telegraph Company, the Signal Service and the Fire Alarm; the seconds transmitting wheel is so cut as to omit the twenty-ninth second, as also the last five seconds of each minute; an additional wheel is placed on the seconds arbor, having a peculiar shaped tooth which comes into play in the sixtieth second of each minute when the proper switch is turned; as the beats progress an observer at a distant station notices the omission of a single beat; by this he knows at once that it is the half minute signal; as some time must necessarily elapse before the signals reach stations so distant as Boston or New Orleans, it follows that all the signals will not be heard at all stations; hence it becomes necessary for the operator to take up the count at thirty, and keep it up until fifty is reached; if more ticks are heard he is made aware that there is at least one more minute to come; should, however, the ticks cease at fifty, he knows that it is the last minute of the hour, and that the next signal will be that made by the transmitting clock as its seconds hand reaches the exact instant of noon. The sender at the clock at that time (ten seconds before twelve) switches out the seconds beat and switches in the minute one; as the seconds hand comes to sixty, the tooth before spoken of causes the current to pass, not merely for a fraction of a second, but for the whole of that time, thus not only distinguishing it from all other signals sent, but also ensuring sufficient time for full contact of the armatures of all relays, time-ball magnets, etc., reached by it.

In connection with the observatory, reached over the wires of the Western Union Telegraph Company, are time balls at Wood's Holl, Mass., Newport, R. I., New York City, Philadelphia, Baltimore, Hampton Roads, Savannah and New Orleans. A ball is also dropped on the Navy Department building in Washington, being connected with the observatory by a special wire.

The connections from the clock are briefly as shown in the diagram on the board: A two pt. repeater of peculiar construction is placed on top of the clock case, the circuit through the coils of its magnets and the points of the transmitting springs being normally closed; as the wheel already described revolves, these points are slightly separated; the circuit is broken and the armature released, the opposite end being drawn down by the tension of a spring, making a circuit through one of the posts upon which the lever strikes and an eight pt. repeater upon a table near by; this in turn makes a circuit through the eight wires leading from it when the proper switches are turned; the other post of the two pt. repeater is used only for dropping the time ball above referred to. The action of this repeater is peculiar, inasmuch as by it the seconds beat, instead of being of but an instant's duration, lasts about one-tenth second, a great advantage in the long distances over which the signal passes. The signal sent to the fire-alarm office sets in motion an automatic apparatus, by means of which all the fire bells in the city are made to strike the hour, the first stroke being very nearly the instant of noon by the clock; of course, some allowance must be made for the action of the striking mechanism, but for all practical purposes the time thus given may be said to be exact. A like signal is sent at 7 A. M. and 6 P. M., and the bells struck at those hours.

The observatory has also in times past used the Jones system for the control of distant clocks with a very considerable degree of success, but as has been the case at Greenwich, experience has led to the abandonment of all attempts at any service outside the observatory, which require the continuous use of a wire and in which the clocks depend for their correctness upon the constant transmission of signals. As I have before said, the Jones system requires that the secondary clocks should be quite as good time-keepers as the primary, which is in itself a grave objection on account of the expense involved. If from any cause there is a fault

on the line (and I need not say that such faults are too apt to occur), the secondaries go on running each with its own error, so that when the line is repaired, the connections again restored, and the current passes, it is not only improbable that all the clocks will show the same minute and second, but in the highest degree probable that they will not do so.

As in these remarks I have assumed that an astronomical observatory must be the base from which time is to be distributed electrically, but little has been said concerning the various systems of so-called electric time which are now so much in vogue. So far as I am aware, no proposal has yet been made to use the clocks of any of these systems in other than detached groups, each having its own master or driving clock, which is not in connection with any source from whence correct standard time is derived; each master clock runs on at its own rate so that no two of half a dozen groups will show the correct time. However practicable it might be to have such a system in a single town or a number of such in a large city, it is quite evident that on the score of expense alone it would be impossible for the observatory at Allegheny or Washington to be connected with such a system in this city; and hence the time furnished by it would not be reliable.

The idea of employing the electric current as a motor for clocks is one that is very entrancing, and that has been carried out with more or less success by the inventions of various persons; reference has already been made to the early system of Wheatstone, as also to that of Hipp, which latter is probably the one that is the most widely employed on the other side of the Atlantic, and to some small extent in this country. Probably most of you are familiar with the system in use in some of the stations of the Pennsylvania Railroad, and if so, you are likewise familiar with the fact that not infrequently one or more of the dials is covered with paper to prevent its incorrect indications from misleading the public. That some of the dials should go wrong is almost inevitable, even where the lines are confined to a single building; and it may be added here that at Greenwich, where there is a similar system used, it has been found necessary to provide other clocks of the ordinary pattern, furnished with the necessary contact arrangements, for use in case of the failure of those operated by electricity. As the published reports of the observatory state that these extra ones are

occasionally used, it is fair to presume that the others have not been found exempt from the failures to which all such arrangements are liable. I think that it may be safely said that experience has developed these facts: (1) that no machinery which depends upon a current derived from a battery for its motive-power is reliable; (2) that no step-by-step apparatus can be depended upon always to perform its functions; (3) that nothing is more certain than that the wires connecting any series of buildings or towns will at some time get out of order. From these facts it can readily be deduced that electro-motor clocks are not to be relied on, except within a very limited sphere, and then only with the most constant and unremitting attention to all parts of the apparatus and connections.

There are undoubtedly some of these clocks that are better than others; one of the latest is that of Spellier of this city; it would seem that in this plan a good many of the mechanical and electrical difficulties which surround the problem have been attacked with a reasonable degree of success; but you will observe in the specimen which is here shown, first, that the master clock is not of a first-class character, being very likely to be affected in its rate by all sorts of influences, and further that it is not in connection with any source whence the standard time is derived. It is true that the time can be obtained from the telegraph office as it is sent from Washington, and the clock then set to correspond; but that is a method which requires too much time and attention; secondly, you will notice that the secondary clock moves but once a minute; that is to say, that it is correct just once in sixty seconds (when I say, correct I mean in accord with the master clock), so that it is impossible to tell what time it is to within nearly a minute; for instance when the hands of the secondary point to five minutes past nine, the other clock may be at five minutes and fifty-nine seconds past; this may be considered sufficiently correct, but if a man was in haste to catch a train he might be easily deceived by thinking that he had nearly a minute more than was really the case. The seconds hand has evidently been abandoned by the inventor of this system, as there is much less expenditure of battery power and certain mechanical difficulties are avoided. There are electrical difficulties also in the way of running a very large number of these clocks on one circuit.

For the reasons that have been cited above, the idea of sympathetic, has been abandoned by those experienced in their workings, for that of synchronized, clocks. The system of Barraud and Lund, in use in London, has already been described. Even that, however, is hardly applicable to our own country, where it is not always possible to receive even a daily signal, for in London it has been found best to correct these clocks hourly.

It may be assumed as the result of many years' experience, (1) that electricity is the most suitable power for controlling clocks at a distance from a central standard, since it is the only available force which acts with sufficient quickness to avoid delay and ensure accuracy; (2) that it must be used as a setting or controlling, and not as a motive-power, inasmuch as sooner or later failures in the connections or breaks in the wires stop the clocks, and hence cause confusion to all who look to them for time; (3) that the cost of maintenance must be reduced to the lowest point, and for this purpose the wires must be in use as short a time as possible, and the least amount of force necessary to set the clocks right must be applied to the secondaries; this also involves the reduction of the amount of attention necessary to be paid to each clock to the lowest possible point; (4) that the system must be such that clocks of differing patterns can readily be included in the circuit, and that the correcting mechanism can easily be applied to them. The system used in London fulfils these functions quite well within its limits; but it has its disadvantages in that its power of correction is limited to the minute hand only, and that for an error not exceeding two minutes. This system has been used at the Naval Observatory at Washington (as have others also), but none have been found to fully cover the requirements of the case until the adoption of the one now in use; this is the Gardner system, by which the correction is made to both seconds, minute and hour hands, and in which there is no limit to the number of minutes that can be corrected, an error of twenty-five minutes being overcome as easily as one of twenty-five seconds!

The clock shown here, is one such as we use in the observatory and on our clock line running to the various public buildings. One of the points of the 8 pt. repeater mentioned above, is connected with this line; where in air it is an insulated wire; elsewhere it is in the Waring cable. There are over eight miles in the

circuit, and upon it more than 350 clocks. In each building entered by the line there is, of course, a local circuit, upon which as large a number of clocks as 100 are worked. There is no complaint as to the working of the system. During the three and a half years that it has been in operation all our trouble has been upon the line; the clocks themselves and the correcting apparatus give us no anxiety. Now, it is quite plain that these line troubles would have caused a system of sympathetic clocks to have ceased operations entirely, while in this plan the clocks have gone on running, and as soon as the line has been repaired, by the simple turning of the proper switches the clocks have been corrected to coincide with the observatory standard. The Pension Office has seventy-five of these clocks, and quite recently the Patent Office (abandoning all others) has put in some 140. There are clocks of this pattern also in use at Newport, Hampton Roads and Savannah, giving, so far as I know, perfect satisfaction, and wherever the observatory signal goes they can be used.

I had finished writing the foregoing remarks and felt that I appreciated, to some degree at least, the necessity that exists for exactness of time, when this cutting from the *New York World* of January 1st, was handed me. I will not weary you by reading it at length; suffice it to say that it discloses a most lamentable state of affairs existing in the public clocks of the great metropolis. The writer states that there is just one place where accurate time can be obtained; and that is from the time ball on the Western Union building, to see which drop hundreds of people assemble on every week day, hardly appreciating, probably, that the signal which drops the ball comes from the Observatory clock, over 200 miles away. When, however, one goes up Broadway and attempts to compare his watch with the various clocks that are to be seen he will have, as the reporter says, "an interesting time." No two of them are alike; and often the different faces of the same clock are discordant. Even the clocks in front of the great jewelry establishments are rarely correct, though they are very imposing, in more senses than one. Here are some illustrations of the way in which New Yorkers are treated in this matter. The clock at the corner of Broadway and Twenty-first Street at noon showed twenty-five minutes past one! The one on the next block was a little nearer correct, showing but four minutes after twelve. The worst

specimen of all was the one in the Fifth Avenue Hotel, which, at high noon, informed the guests of that establishment that the hour was twenty-five minutes past ten! Well may it be said that reform in this matter is imperatively necessary!

Now that we have the system of standard time in use, an observatory must necessarily be the source of this time, and it becomes more than ever important that communication with well-established institutions of this sort should be regular and constant. There should be no such state of affairs as has been shown to exist in New York, nor is there any necessity therefor. The observatory at Washington was established on account of the needs of the navy for an accurate standard of time, and following the example of other Government institutions, it naturally gives to commerce its assistance when needed. The time balls already alluded to are but the beginning of what it is hoped will be a comprehensive system embracing the whole coast, so that in every commercial city there shall be a like installation. All that is wanted is an appropriation of the money that has been asked for, and which it is to be hoped will be granted. Nor is this the only function of the observatory, as has been shown already in the statement of the extent to which its time signals are distributed. Its system is the result of much study and experiment, and is believed to be fully suited to the needs of the community which it can serve, scattered as it is over such wide extent of country, and necessitating such long-distance transmission of the signals.

Is ENGINEERING on the DECLINE?

By William Barnet LeVan.

[*Read at the Stated Meeting of the* Franklin Institute, *Wednesday, April 18, 1888.*]

There is probably no profession which is so little understood by the general public as that of engineering. The question of sound and advanced engineering is one that greatly affects a community whose prosperity depends mainly on the efforts of practical science. Ability and integrity are indispensable qualifications in those who are entrusted with the expenditure of large sums of money in works of public utility. A great work that involves immense original outlay and large yearly expense of maintenance, may be made one per cent. more profitable by the best engineer than by the second best; and out of this one per cent. a liberal amount may well be paid the former for his superior abilities. Therefore, all that the best men have done in the past should be known and compared with our present practice, to prevent us from beginning behind the age and help us to make further progress.

The object of my paper to-night is to call the attention of the public at large to the system in which the construction of our railroads and other incorporated companies are now projected and carried out. It is evident that the first and principal object in most of these works is, that they shall be made productive to those through whose instrumentality the legislative powers are obtained, with but a remote regard to the interests of those who may ultimately become the proprietors of shares, or to the benefit or convenience of the public.

IS ENGINEERING ON THE DECLINE?

The writer is not willing to assert or admit that such is the case, and many grand triumphs of modern engineers might be cited to prove that there has been no decadence in engineering skill.

But the writer does assert that many important public and private enterprises which might be made commercially profitable to investors in them, and of great advantage to the public and to all parties concerned, are handicapped at their outset by reason of the

fact that the engineering departments are entrusted to unskilled and incompetent hands; and the truth of such assertion finds conspicuous illustration in several enterprises of a public and private character that are being conducted, and are in progress in our midst.

This may appear to be a somewhat broad assertion, but it is, nevertheless, one amply justified by the facts which are open to the consideration of all who choose to seek for them.

Let any fair and impartial first-class engineer examine and report upon our public works and those of incorporated companies, and in a majority of cases the verdict in a condensed form will be that they are extravagantly arranged, located and operated.

MECHANICAL ENGINEERING.

What is wanted is economical power; the fact is that but very few manufacturers who use steam power, and especially those controlled by incorporated companies, are aware to what extent the economy of a mill or works, run by any given engine and boilers, is affected by circumstances under which it is located and erected to produce the best results as to wear and tear as well as fuel consumption.

Very many persons—and persons, too, who ought to know better—imagine that a steam engine which is good for one situation is good for all, whereas a greater error than such an assumption can scarcely be imagined. It is true that there are certain makes of engines which may be relied upon to give moderately good results in almost any situation; but not when the *best* results are desired—and the best results always *should* be desired in any manufacturing establishment.

The selection of an engine for the performance of any given work, due regard being of course paid to the nature of the work to be performed, also, how far it is advisable to divide the total power required amongst a number of engines for the purpose of saving shafting and for general convenience, is of itself a most important one, and demands independent consideration.

The next point to be decided is, whether a condensing or a non-condensing engine is to be employed. Except under conditions in which the exhaust steam from a non-condensing engine can be turned to good account for heating purposes, it may safely be

asserted that in all instances where a sufficient supply of condensing water is available at a moderate cost, the extra economy of a well-constructed compound condensing engine will fully warrant the additional cost involved, especially if the power exceeds 100 horse-power.

Boilers are an important factor in the production of economical power. The importance of the use of *high pressure steam* cannot be too constantly urged upon engineers and manufacturers, and that the employment of low pressure steam to run engines is extremely wasteful; yet clear as this is or should be to all intelligent engineers and steam users, they do not recognize its truth. To illustrate! When using steam at forty pounds above atmospheric pressure in a non-condensing engine, one-third of the whole of the power is consumed in overcoming the atmospheric pressure; while if steam were used at 100 pounds to the square inch, one and one-tenth of the power would be so wasted, due to the pressure of the atmosphere (14·7 pounds) being a greater percentage if a low pressure is used than in the case of a high pressure.

It has been proven, both in practice and theory, that the greater the difference between the steam pressure on the piston and the resisting force of the condenser or atmosphere, the higher will be the mechanical efficacy of the steam, hence the necessity of employing high pressure steam in order to obtain the fullest effect of expansion.

It is a well-known fact that the secret of economy in running steam engines lies in the adoption of the highest practicable pressure of steam, thorough jacketing, the earliest cut-off at which the engine will run, and as perfect condensation of steam as possible after the steam has done that work.

No engine can run economically at a high grade of expansion except it be fitted with a condenser; for the greatest economy of expansive working lies in expanding below the pressure of the atmosphere.

Having decided on your motive-power, a location for your works should be in order; in Philadelphia a large river front is presented, and, therefore, in this city there should be no difficulty on this point.

The most important items of expense in any large establishment run by steam power are the *fuel* and *water*, especially in cities where the latter is charged by the cubic foot.

There is an old saying, "That the best is not good enough." It may be assumed as a fact that a steam engine employed for driving a mill or works of any kind cannot be too good, the saving effected by the economical running of the best engines in the great majority of cases enormously outweighing the interest on their extra first cost. So few persons appear to have a clear idea of the vast importance of economy of fuel in large works, that I cannot better illustrate than by showing the saving that can be made in large establishments by the use of the most modern economical make of engines.

COMPARISONS.

(1) We will take the Brush Electric Light Company, Johnson Street, west of Twentieth Street and south of Market Street, this being a modern plant with ample capital behind it.

As regards the location of these works for supplying arc lights, for all intents and purposes they could just as well have been located on the Schuylkill River, where more ground could have been obtained for the amount paid for the present location, besides the advantages of *free water* and cheaper fuel, as the latter could have been set down in their works by boat or rail, thus saving extra handling and cartage.

MOTIVE-POWER.

The present plant consists of ten non-condensing automatic cut-off engines, to wit:

Eight Porter-Allen engines of forty horse-power each, of the following dimensions:

Diameter of cylinder in inches,	8
Length of stroke in inches,	16
Revolutions per minute,	290

Two Corliss engines, connected at right angles to the main-shaft, of the following dimensions:

Diameter of cylinder in inches,	23
Length of stroke in feet,	4
Revolutions per minute,	75
Boiler pressure in pounds per square inch above atmosphere,	105

These two engines are capable of developing each 250 horse-power with ease, and in case of an emergency 800 horse-power could be realized.

The eight Porter-Allen engines are only run between 5 and 10 P.M., when the demand for light is the greatest.

The average horse-power developed during the twenty-four hours will be about 400, and as the Corliss engines are kept continuously running, we will base their cost for fuel on these data.

The following indicator diagram (*Fig. 1*) from a non condensing Corliss engine, is a fair sample of the distribution of steam in the cylinder.

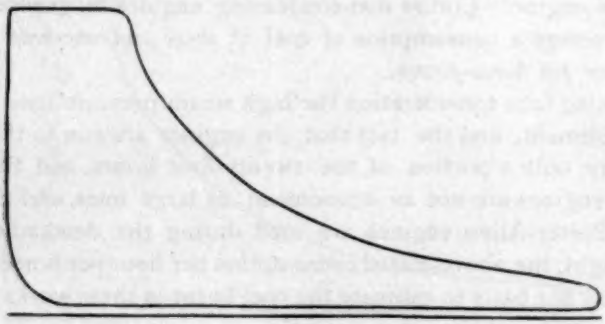


FIG. 1.

Diameter of cylinder in inches,	22
Length of stroke in inches,	48
Revolutions per minute,	78
Boiler pressure in pounds per square inch,	60
Coal per hour per horse-power in pounds,	3

BOILERS.

The boilers are sixteen in number, consisting of four Babcock & Wilcox Company make, and rated by them at 300 horse-power, based on 11 square feet of heating surface per horse-power and 108 square feet of grate surface.

There are also six horizontal flue boilers, 40 inches in diameter and 17 feet long, containing nineteen flues of 4 inches diameter and 115 square feet of grate surface.

There are also six horizontal flue boilers, 42 inches in diameter and 20 feet long, containing nineteen flues of 4 inches diameter and also 115 square feet of grate surface. The steam pressure carried averages about 105 pounds above the atmosphere and according to calorimetric test averages about three per cent. of water.

FEED WATER.

The charge for feed water for boilers in Philadelphia is based on the maximum horse-power developed, and the rate is $3 per horse-power per annum; therefore, the water rent for this works will be as follows:

$$400 \times 3 = 1{,}200 \text{ dollars per year.}$$

COAL CONSUMED.

The consumption of coal can be very nearly arrived at by the type of engine. Corliss non-condensing engines as generally run will average a consumption of coal of *three and one-half pounds per hour per horse-power.*

Taking into consideration the high steam pressure used in this establishment, and the fact that the engines are run to their full capacity only a portion of the twenty-four hours, and that the small engines are not as economical as large ones, and that the eight Porter-Allen engines are used during the demand for the most light, the above-stated consumption per hour per horse-power will be a fair basis to estimate the coal burnt in these works during the twenty-four hours run.

The coal used must be hauled in carts, say one-half mile, and taking into consideration the good quality of coal employed, $4 will be a fair price per ton delivered. The cost of fuel will be as follows:

Horse-power,	400 ×	3·5 =	1,400 pounds per hour.
	1,400 ×	24 =	33,600 pounds per day.
	33,600 ×	365 =	12,264,000 pounds per year.
	12,264,000 ÷	2,000 =	6,132 tons per year.
	6,132 ×	4 =	24,528 dollars per year.

PROPER LOCATION OF WORKS.

Now, had these works been placed on the river front, as they should have been at the time of their erection, more ground could have been had for the outlay made for their present location, with the advantages of *free boiler feed water*, and coal at a less price per ton delivered direct in the works by rail or boat.

And another, a very important advantage, to wit: in the place of using non-condensing engines, compound condensing engines could have been employed with but a slight advance above the present cost of plant.

A good condenser will increase the economical power of an engine from *twenty* to *forty per cent.*, or for the same power effect a corresponding saving in the amount of steam used and fuel consumed.

Therefore, in plain terms, if *three pounds* of coal be necessary per hour per horse-power, with a well proportioned and erected non-condensing engine, then *two and one-half pounds* of coal will develop the same power with a first-class condensing engine, as will be shown by the following indicator diagram from a Corliss condensing engine.

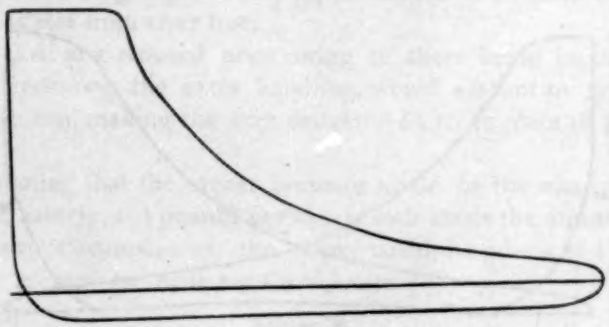


FIG. 2.

Diameter of cylinder in inches,	20
Length of stroke in inches,	48
Revolutions per minute,	61
Piston speed in feet,	488
Pressure of steam per square inch in pounds,	89
Vacuum per gauge in inches,	27
Indicated horse-power,	220
Coal per indicated horse-power per hour in pounds,	2·295

ADVANTAGES OF THE COMPOUND STEAM ENGINE.

(1) It furnishes a better working engine, mechanically, for utilizing the benefits of the expansion of high-pressure steam.

(2) Independently of mechanical consideration, it is more economical to use steam expansively in a compound engine than in any form of the ordinary engine.

COMPOUND CONDENSING ENGINES.

The following diagram was taken from a compound condensing Corliss engine. The mill was origipally driven by a pair of horizontal slide valve engines, with cut-off of the following dimensions:

Diameter of cylinders in inches,	24
Length of stroke in feet,	4

In order to get good results, it was arranged to erect boilers adapted to carry at least 160 pounds steam per square inch, and to replace one of the twenty-four inch slide valve cylinders by a Corliss cylinder fourteen inches in diameter and four feet stroke, the new cylinder was steam jacketed, and the cranks being at right angles a receiver was placed between the engines.

This alteration has been found to be a very great improvement, and the following diagrams (*Figs. 3* and *4*) taken from the altered engines, speak for themselves.

FIG. 3.

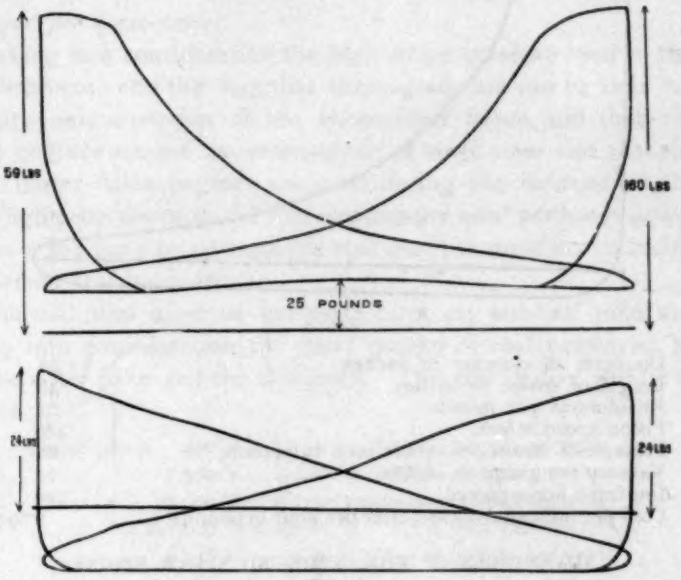


FIG. 4.

It will be seen that running sixty revolutions per minute, and with 165 pounds of steam in the boiler, the non-condensing Corliss cylinder indicates 125·2 horse-power, with a mean pressure of fifty-six pounds, and the condensing cylinder 131·1 horse-power, with a mean pressure of 19·75 pounds, or, collectively, 256·3 horse-power. About one pound of difference of pressure is shown between the two cylinders.

This engine has been frequently run up to 350 horse-power, when all the mill machinery has been on at once. The con-

sumption of water so stated has been measured, and found to be about thirteen pounds per hour, per indicated horse-power, equivalent to a consumption of 1·3 pounds of coal per hour per indicated horse-power, with a boiler evaporation of ten pounds of water per pound of coal. The steam was very dry and the indicator cards account for but 10·33 pounds of water per hour per horse-power developed.

Had the Brush Electric Light Company, therefore, been located at the river and fitted up to run compound condensing in the place of non-condensing engines, the cost per annum would have been:

(1) Water from river free.

(2) Coal at a reduced price owing to there being no cartage, which, including the extra handling, would amount to, say, fifty cents per ton, making the cost delivered $3.50 in place of $4 per ton.

Assuming that the steam pressure would be the same as now carried, namely, 105 pounds per square inch above the atmosphere, under any circumstances, the power could be produced for *two pounds of coal per hour per horse-power.*

Then

400 ×	2 =	800 pounds per hour.
800 ×	24 =	19,200 pounds per day.
19,200 ×	365 =	7,008,000 pounds per year.
7,008,000 ÷	2,000 =	3,504 tons per year.
3,504 ×	3·50 =	12,262 dollars per year.

Thus the saving, if located on river front fitted with compound condensing engines as compared with the present location with non-condensing engines, would be as follows:

Cost at present location for water,	$1,200 00
Cost at present location for coal,	24,528 00
Total cost,	$25,728 00
Cost if located at river,	12,262 00
Saving per year,	$13,466 00

In fact it would pay this company at the present time to excavate on their present premises to the depth of fifteen or twenty feet, place new compound condensing engines in said excavations and make a connection to the river Schuylkill by a line of pipe for their condensation water. This could easily be done as the curb

line on Johnson Street is but thirty three feet above low-water mark. If they excavated twenty feet the water would only have to be lifted about, say, eighteen feet at low water.

I make this statement based on the increasing business of the company. I also understand it is their intention to add 500 additional horse-power in the near future.

The next case of any magnitude is the plant of the Philadelphia Traction Company, located on Market Street below Twentieth Street, as to which, so far as the work to be performed is concerned, location would be immaterial.

MOTIVE POWER.

The steam engines are of the same make and about the same horse-power, namely, two non-condensing Corliss engines, with the exception that they are separate in place of being coupled to one shaft, and the power is transmitted by gearing in place of a belt, as in the case of the Brush Electric Light Company; in all other respects they are substantially the same, and are rated also at 250 horse-power each. The dimensions are as follows:

Diameter of cylinder in inches,	24
Length of stroke in inches,	48
Revolutions per minute,	65
Boiler pressure above atmosphere in pounds,	90

BOILERS.

The boilers are six in number and are commonly called "Two-story" boilers. The lower horizontal shell is 14 feet in length and 4 feet in diameter, the upper horizontal shell is 15½ feet long and 4 feet in diameter, and the two are connected by four necks, 14 inches diameter, about 12 inches long; the lower shell contains forty flues, four inches in diameter.

This style of boiler is not as economical as those of the Brush Electric Light Company, and will consume more coal per hour per horse-power.

The engines in this works, considering the type of boiler and the slow piston speed, will require about four pounds of coal per hour per horse-power.

The average run per day will be about twenty-two hours, and develop in round numbers, say, 400 horse-power. The cost of coal delivered per ton will average about $3.75.

Then we have cost of fuel and water, as follows:

Water rent at $3 per horse-power per annum,

$$400 \times 3 = 1{,}200 \text{ dollars.}$$

Coal at the rate of $3.75 per ton.

400 ×	4 =	1,600 pounds per hour.
1,600 ×	22 =	35,200 pounds per day.
35,200 ×	365 =	12,848,000 pounds per year.
12,848,000 ÷	2,000 =	6,424 tons per year.
6,424 ×	3·75 =	24,090 dollars per year.

Had this plant been located at the river front, and been fitted with compound condensing engines, the cost per year would have been as follows:

400 ×	2 =	800 pounds per hour.
800 ×	22 =	17,600 pounds per day.
17,600 ×	365 =	6,424,000 pounds per year.
6,424,000 ÷	2,000 =	3,212 tons per year.
3,212 ×	3·75 =	12,045 dollars per year.

Water rent free from river.

Then the saving would have been, if located at the river front, and by the use of compound condensing engines, as follows:

Cost per annum at present location:	
Water rent per year, ...	$1,200 00
Coal per year, ...	24,090 00
	$25,290 00
Cost at river front, ...	12,045 00
A saving per year of	$13,245 00

I will next refer to the proposed Edison electric lighting plant on Sansom Street above Ninth, Philadelphia, as described in *Philadelphia Press* on March 4, 1888, as follows:

"The building will have a front of seventy feet on Sansom Street, and will extend 100 feet back toward Walnut Street. Its cornice will tower 114 feet above the pavement, overshadowing all the lofty roofs in the neighborhood.

"Twenty engines, of 250 horse-power each, will be placed on the first floor. Forty dynamos, with a capacity of 1,500 lights each, or a total capacity of 60,000 lights, will rest on the second floor. On the floor above the dynamos will be the workshops, where wire and conduits are prepared for laying in the streets and

making connections with houses. Clear up on the fourth floor huge boilers, with a capacity of 5,000 horse-power, will be placed. In the fifth floor will be stored over 1,000 tons of coal at a time. The sixth floor, where light and air will abound, as its windows will look twenty feet above the roof of the Continental Hotel, will contain the general offices of the company and space for its clerical force.

FOUNDATIONS ENORMOUS AND SOLID.

"This sounds like an amazing way of erecting a plant, with huge boilers and tons of coal in the air, but this reversal of the ordinary arrangement of machinery is due to the necessity of concentrating enormous power within a limited space. It also necessitates construction of the most massive kind. In the first place, the whole lot will be covered with a deep bed of concrete, four feet in vertical thickness. Resting on this bed will be the foundation walls, five feet thick. The twenty engines on the first floor, which will each hum at the rate of 200 revolutions a minute, are of the high-speed Armington & Sims type. They will each be firmly planted on a concrete monolith fifteen feet square. These twenty monoliths will rest upon a bed of sand one foot thick which in turn rests upon the bed of concrete four feet thick. The dynamos on the floor above the engines will weigh seven tons each and will make 650 revolutions a minute. They will rest on heavy iron beams supported by iron pillars, each pillar being capable of upholding 500 tons. Other pillars and beams support the floors above the boilers, furnaces and coal. The coal is to be driven upon scales, weighed and dropped into a pit. Chutes will be so arranged that the coal can be readily loaded on elevators and carried to the fifth floor. There the coal will be dropped into bins, from which a pipe runs at an inclination to the furnace of each boiler. All this machinery for delivering and feeding the fuel under the boiler will be strongly but simply designed to save time and handling.

FUEL AND BLASTS FOR THE FURNACES.

"On the third floor there will be placed two blast fans, capable of driving 50,000 cubic feet of air per minute into the furnaces. The smoke and other products of combustion will be carried from the furnaces into two chimneys of nine feet internal diameter.

These chimneys or smoke stacks make an original detail of the building, for they will appear as bay windows, starting at the third floor and reaching to the roof. These apparent bay windows will be at the rear of the building; the bay windows shown in the front elevation will contain spiral staircases. There will also be a passenger elevator in the front portion of the structure.

"Pipes will carry the steam from the boilers to the engines on the first floor, and a huge exhaust pipe will rise from the engines to the top of the building. This exhaust pipe will be four feet in diameter at its top, and probably there is no exhaust pipe in use in Philadelphia as large as this.

HOW THE CURRENT IS DISTRIBUTED.

"Every known scientific appliance will be used to regulate the distribution of electricity and to secure perfect uniformity and regularity in the brilliancy of the lamps. Edison's skill in this direction is pre-eminent, and his inventions will be utilized in every possible way. There will be thirty-five great feeding mains running from the station. Each feeding main consists of three bars of copper as thick as a man's thumb. To each of these mains a regulating apparatus is specially attached, so that the pressure is constantly kept at exactly the same point, whether one lamp or 1,000 may be burning on a main. In other words, this regulating apparatus keeps the quantity of current supplied to a main exactly proportioned to the demand.

"When this great station on Sansom Street is completed, it will cost the company about $1,000,000. It will be one of the sights of the city, and will dwarf the wonders of the electrical exhibition four years ago, which brought thousands of visitors to Philadelphia. But as it will be, this plant is only the beginning of the plan of the company. It will supply only the central portions of the city, and it is expected that other stations nearly, if not quite as large, will be erected in Kensington, Richmond, Spring Garden, Northern Liberties, Germantown, Southwark, West Philadelphia and elsewhere. Already the company has expended $250,000 in copper conductors, eleven miles of which are laid under Chestnut and Walnut Streets, between Twentieth and Fourth Streets. During the coming summer twenty miles more of conductors are to be laid, extending between the Delaware and

the Schuylkill, under Market Street from the Delaware to the Public Buildings, and on intersecting streets connecting with Spruce, Pine and South Streets."

MOTIVE-POWER.

In regard to the Armington & Sims engines, I have no indicator diagrams to refer to, except such as are illustrated in their circulars of date about 1885; their engine was entered for competition at the International Electrical Exhibition of the FRANKLIN INSTITUTE in 1884, but was withdrawn before the tests of engine were made.

The following diagram, *Fig. 5*, was taken from one of their engines, 12 x 12 inches, running 350 revolutions per minute,

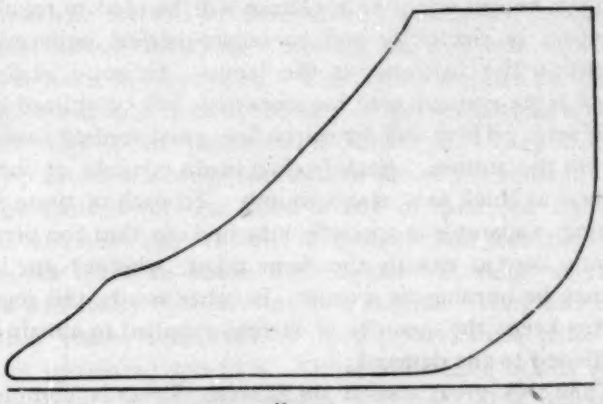


FIG. 5.

coupled direct to one of Edison's large dynamos; mean effective pressure on piston, 45·28 pounds; indicated horse-power, 106·6.

The following diagram, *Fig. 6*, was taken in September, 1883, by Prof. Thurston, who examined, by request, the design, construction and workmanship, to observe their power of automatic regulation, and to determine what power was demanded in operating electric lights.

The engine was 9½ x 12 inches, running 280 revolutions per minute. Water consumption per hour per horse-power, when fifty lights were on, was, according to the cards, 21·5 pounds. Thomson-Houston dynamos of twenty-five lights each.

This engine, as will be seen from the indicator diagrams, is of

the single valve type, the valve being hollow piston valve, and therefore cannot be as economical as the before described engines.

On page 9 of their circular it is stated: "The engines are adapted to work under the highest pressure, if required. By the

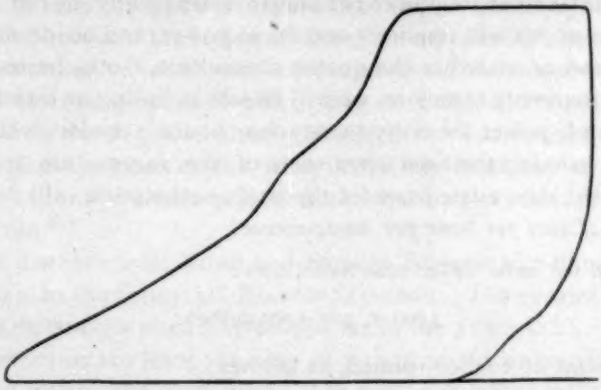


FIG. 6.

use of suitable condensing apparatus, the power of these engines can be increased twenty-five per cent."

The following diagram, *Fig.* 7, is from an Armington & Sims condensing engine, built in 1886, of dimensions as below:

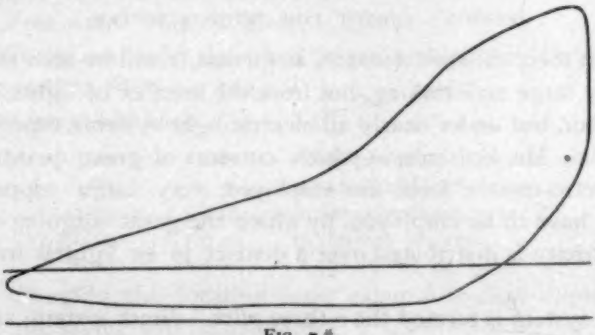


FIG. 7.*

Diameter of cylinder in inches,	18·5
Stroke in inches,	30·
Revolutions per minute,	129·
Boiler pressure per pound,	76·
Vacuum in inches,	25·5

* The sizes of the foregoing diagrams have been made to conform to the pages of the JOURNAL. L.

The construction of boilers to be used is not mentioned, but I understand they are to be of the water-tube type, and to have a forced blast.

The number of lights of this system to the horse-power, average ten of sixteen candle-power per lamp; consequently, to run 50,000 lights as above will require 5,000 horse-power, and no doubt in a short time, as stated in the quoted description, 6,000 horse-power will be required; therefore, we will be safe in basing an estimate on 3,000 horse-power for every twenty-four hours. And with the coal used in banking the fires when some of the engines are standing during the day, a fair basis for the coal consumption will be *four pounds of coal per hour per horse-power*.

Then we have water rent as follows:

$$3{,}000 \times 3 = 9{,}000 \text{ dollars.}$$

Amount of coal consumed, as follows:

3,000 ×	4 =	12,000 pounds per hour.
12,000 ×	24 =	288,000 pounds per day.
288,000 ×	365 =	105,120,000 pounds per year.
105,120,000 ÷	2,000 =	52,560 tons per year.
52,560 ×	4·50 =	236,520 dollars per year.

EDISON'S DIRECT LOW-TENSION SYSTEM.

From the published account, as quoted, it will be seen that this is a very large undertaking, not from the number of lights, 60,000 in number, but under nearly all electric-light systems, especially in those like Mr. Edison's, in which currents of great quantity and low electro-motive force are employed, very large copper conductors have to be employed, by which the great outgoing current of electricity is distributed over a district to be lighted from the station.

The system is termed the "three-wire" direct system, and is of peculiar and of interesting construction.

My object in giving the above description is to show that on account of the low electro-motive force, expensive conductors as above described have to be used, and as a means of saving first outlay the works containing the motive power and dynamos are as a general thing placed as near the centre of the district to be lighted as is convenient.

Now I maintain that by locating the station at the river front the additional cost of increased size or number of conductors will be saved in the first year's run based on 50,000 lights.

Not being in the confidence of the Edison management, I am unable to state the cost per lineal foot of such conductors, including junction boxes and the laying of same, but am satisfied, from a personal examination of the conductors and boxes and the connections as are now in process of being laid on Sansom Street, that in addition to the $250,000 already invested an additional $125,000 would place the plant on the Schuylkill River front, say at Sansom Street, and would nearly pay the additional cost of same, in the first year's run.*

The distance from Ninth and Sansom Streets, according to the city plan, to the Schuylkill River is 7,600 feet. The greater portion of this distance is already provided for in the $250,000.

Now let us see what the cost of power would be provided the location was on the river front. The cost, with additional property over that now proposed, would not exceed the cost of present location.

The cost of first-class compound condensing engines and steam generators would be the same as those contemplated, and the advantages would be as follows:

(1) Free water from the river.

(2) Cheap coal price delivered by rail or boat would not exceed at present time $3.75 per ton.

Then we would have

3,000 ×	2 =	6,000 pounds per hour.
6,000 ×	24 =	144,000 pounds per day.
144,000 ×	365 =	52,560,000 pounds per year.
52,560,000 ÷	2,000 =	26,280 tons per year.
26,280 ×	3·75 =	98,550 dollars per year.

By changing the location, and using first-class engines and boilers, the saving will be as follows:

Cost at proposed location, water rent,	$9,000
" " " coal,	236,520
	$245,520
Cost at river front,	98,550
Saving per year,	$146,970

*See note at close of paper. L.

CIVIL ENGINEERING.

In building a railroad there is a peculiar condition relating to its economical running, in which it differs from the economical working of the ordinary manufacturer. A railroad must be as nearly straight as possible when it is first constructed, as improvements made afterwards cost double, as, for instance, the straightening of the New York Division of the Pennsylvania Railroad between this city and Jersey City, now under way.

A manufacturer of cotton or woollen goods, or of an electric light plant, may, at any time, add expensive and more economical machinery or buildings, and thereby produce a better or a cheaper article or light, but in building a railroad, especially if for a city terminus, this cannot be readily done. If the road bed is not originally well laid out and constructed, and capable of being run cheaply and safely, it can only be re-organized at a cost equalling that of a new line.

Let us take as an instance the proposed terminus of the Reading Railroad. This company is engaged at the present time in buying and securing expensive properties along the proposed route at extravagant prices, and when secured, an enormous outlay will be required to erect the superstructure of the proposed road-bed, as shown in the Philadelphia *Times* of March 22, 1888.

This plan will necessitate two reverse curves, which, at the high speed required on the proposed iron structure, will require a gang of boiler riveters constantly at work to make it stable for the service required, as is best illustrated on the elevated iron portion of the Pennsylvania Road at Twenty-second and Twenty-third Streets, where men are constantly employed redriving rivets in the structnre; also on the elevated road in New York.

Every one knows that when the Tabor branch of the Reading Railroad was built, it cut through Mr. Clayton French's property, which was the cause of much litigation; whereas, they could have avoided it at much less cost by going around it, but their Chief Engineer of the road, Mr. Lorenz, said "No! To go around will cause a detention of at least five minutes for each train, and twenty trains a day means 100 minutes," and the road was built straight.

Now, this company can secure an entrance into the heart of the city, without one cent of cost for the right of way, and a straight line at that, by coming in under Broad Street. By so doing, they

remove from public sight the locomotive and cars, and their existence will almost be forgotten.

A tunnel could be built from a point on Broad Street, where it intersects the Richmond branch, a distance of about three miles, at a cost of about $4,000,000, whereas the present proposed route will cost at least $10,000,000, exclusive of stations, etc.

This tunnel line would not involve the payment of damages to private property, and it would be entirely free from all grade crossings, or interference with the occupants of private houses, and the noise of passing trains, etc.

The tunnel plan has many advantages and should be preferred upon the grounds of taste and propriety alone, as it will spare us the boiler iron architecture that will cover over many of the principal thoroughfares, such as Arch, Race and other streets.

The following cut, *Fig. 8*, shows a section of tunnel road-bed and proposed station at or near Arch Street. The upper section shows the road-bed at Broad and York Streets, the difference in the height of the two road-beds being the difference in grade between the two points.

Stations can be located at any convenient points along the proposed line, access being had by stairs or elevator as may be desired.

[The estimate for additional cables, given on page 41, is based on statements made in a pamphlet entitled "A Warning from the Edison Electric Light Company," issued by the company within the last three months. On page 57, we read as follows: the "Price of Underground Conductors (complete) per lamp $8.85," at Denver, Col., for 10,000 lights, and at Minneapolis, Minn., for 21,700 lights, feeders and mains, "$2.40 per light," estimate made May, 1887. Also, on page 59, "Edison 3-Wire Direct System, $4.40 per lamp," "September 1, 1887."]

COMMENTS OF PROF. WM. D. MARKS ON MR. LEVAN'S PAPER.

OFFICE OF THE EDISON ELECTRIC LIGHT COMPANY, OF PHILADELPHIA,
435 CHESTNUT STREET,

PHILADELPHIA, June 13, 1888.

Dr. Wm. H. Wahl, Secretary FRANKLIN INSTITUTE.

DEAR SIR:—Mr. W. Barnet LeVan's assumptions with regard to the Edison Electric Light Company's new central station are so

wholly incorrect as not to admit of being used as the basis for any argument. I cannot make any further reply than to express my extreme regret that the Publication Committee, in spite of my repeated protests, should have permitted the publication of an attack upon the business of this company by a person absolutely without the means of knowing, and who has made no attempt to obtain, the necessary data for a fair discussion. Kindly publish this as an appendix or note to that part of Mr. LeVan's paper relating to the Edison Company. Yours truly,

WM. D. MARKS, *Supervising Engineer.*

A STATEMENT BY THE COMMITTEE ON PUBLICATIONS.

THE Committee on Publications desires to explain that, in accordance with the usual custom, the paper of Mr. LeVan, which had been read at one of the stated meetings of the INSTITUTE, was submitted to it for publication in the JOURNAL; that several protests against the publication of the paper were received and considered; and that it was decided to publish the paper and to give the protestants the opportunity of making reply thereto in the same impression of the JOURNAL.

The Committee's proffer elicited a reply from Prof. Marks, printed above. In view of the statements contained therein the Committee deems it proper to state that, in its judgment, the paper of Mr. LeVan appears to be a criticism of the engineering methods of certain local companies, based largely upon descriptive accounts of the same that have appeared in the daily press; and that it contains neither personalities, nor any attack upon the business of any person or company. The Committee, therefore, sees no valid reason for reversing its decision to publish Mr. LeVan's paper.

THE COMMITTEE ON PUBLICATIONS.

PHILADELPHIA, *June, 27, 1888.*

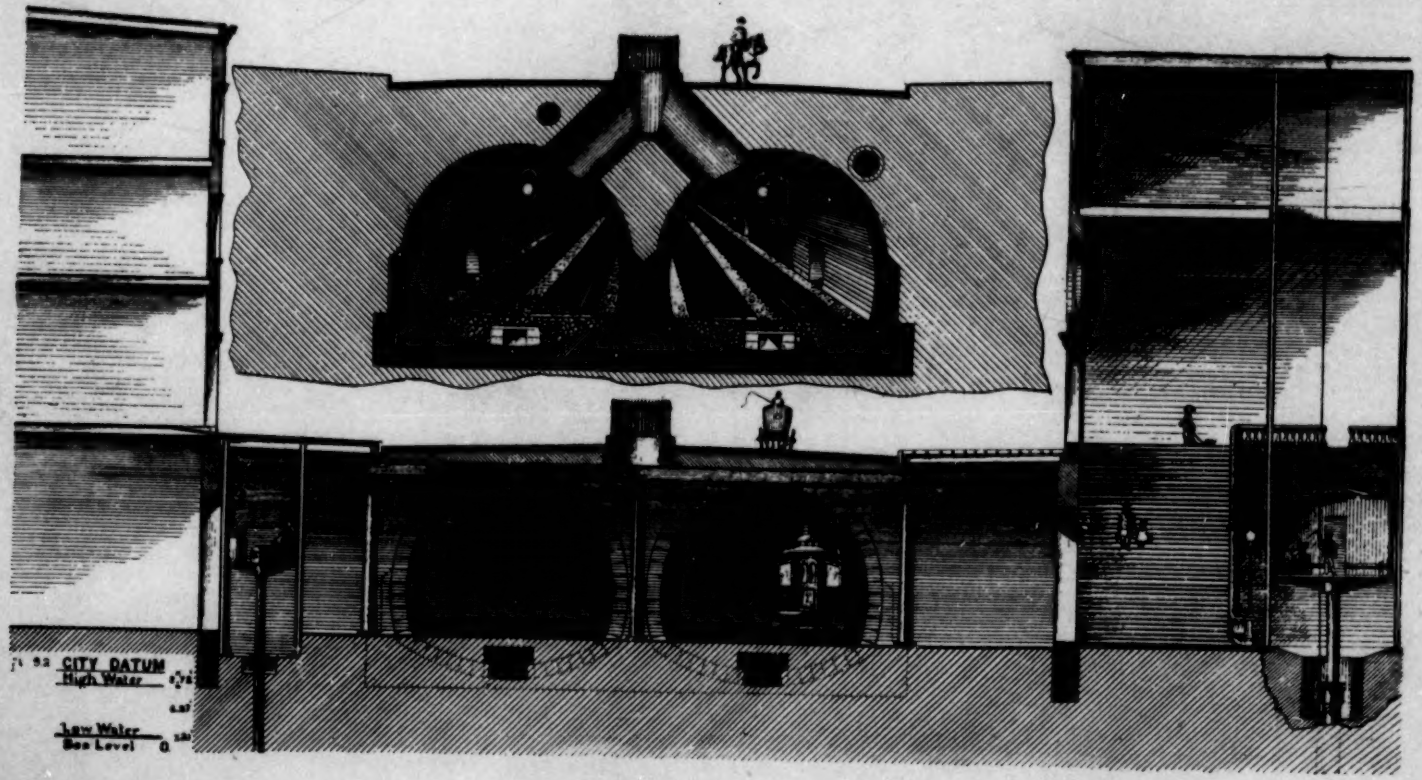


FIG. 8.

MOVEMENT OF UPPER AIR CURRENTS.

By H. Allen Hazen.

Prof. Ferrel says, An. Rep. C. S. O., 1885, p. 259: "The principal cause of the progressive motions of cyclones is undoubtedly the general motion of the atmosphere in which the cyclone exists. The velocity of progressive motion, however, is generally much greater than that of the general motion of the atmosphere, even up at a considerable altitude." Prof. Ferrel finds that Prof. Loomis has obtained a velocity of twenty-six miles per hour for storm centres and he obtains, from a table on p. 213, that this velocity for the middle latitudes of the United States would be found at an altitude of 16,400 feet, and he considers that if the progressive motion of the storm is due to that of the upper air currents, then "the centre of the controlling power of the cyclone must be at that altitude." Without at present considering the theoretical determinations of velocity in the upper strata, it will suffice for my purpose to note that, according to Prof. Ferrel's views, there is a most intimate relation existing between the motions of the upper air strata or clouds and that of the storm on the earth. It is very easy to see that, since the motion of the upper clouds is far in advance of that of the storm, if only we can correlate that motion with that of the storm, we shall have a most important aid to weather and storm predictions. It shall be the object of this paper to make a beginning in this study, with the hope that others may be interested in the question, and also expecting sometime to continue it farther.

One of the most important considerations is as to the directions of the uppermost clouds when compared with the currents at a mile or a little more. We very frequently find the lower clouds going in directions differing greatly from that of the upper clouds, but it seems probable that in most of these cases the lower clouds are less than 6,000 feet altitude. The cirrus often attains a height of five or six miles, and the study of the movements of the upper strata would be much simplified if we could obtain the relation, if any subsists, between the movements of the upper and lower currents. Fortunately we have in this country a peak, well isolated, rising to a height of 6,300 feet, and offering, it would seem, a most inviting and excellent vantage ground for observation. I have studied the

records of the movement of upper clouds and the wind at Mt. Washington, and have found a remarkable uniformity in the motions, *i. e.*, almost without exception the two motions either agree or differ by only 45°. It is easy to see that the recorded difference of 45°, *e. g.*, W. for the wind and N. W. for the upper cloud, may mean a difference less than 5° between the two, for the wind may be N. 70° W., which would be recorded as W., while the clouds may be N. 65° W., which would be recorded as N. W. The actual difference in this case would be only 5°. It would seem a very good plan to make an additional record at such stations as Pike's Peak and Mt. Washington, giving the actual angle between the two directions, or it may be better yet to give the wind as so many degrees east or west of the north and south points, and likewise the clouds. The exceptions to the usual rule, that the upper currents and those at 6,300 feet have the same direction, are very interesting and need to be studied by themselves. We may consider, in general, that above the height of 6,000 feet there is very little variation in the direction of motion of the air strata from that height up to the limit of plainly visible cirrus cloud. I am not aware that we have any records of the motion of the highest ice spiculæ as compared with the upper cirrus, but this would seem a valuable desideratum.

Another important fact to be determined is the relation, if there be any, between the surface wind and the air current at 6,000 feet. Prof. Loomis has made such study by comparing the winds at Burlington and Portland with those at the same time on Mt. Washington, but this method of research can hardly be considered satisfactory. The region within 100 miles of both these stations is very mountainous and the proximity of Portland to the sea, where the actions of storms cannot be determined, precludes the possibility of satisfactory determinations. It would seem, however, that if we project the direction of the upper clouds on charts containing isobars, we shall have a good opportunity of studying the relations between them, and if we know, as we do, the relations between isobars and surface winds, we can immediately ascertain the relations between upper current directions and that of the surface winds. A discussion of this question, however, must take into consideration the fact that in the centre of a high area there are frequently no clouds and in the centre of a low area

there are so many dense clouds that often no motion can be determined. Nevertheless, this loss is not serious, because the direction at some distance will in general be that near the centre. The gap in the case of a clear sky may readily and inexpensively be filled by observations of toy balloons. It is probable that, at an expense of less than ten cents, a balloon can be made to rise to the height of 3,000 feet, and up to 6,000 feet at less than twenty cents. When we consider the enormous advantage to be derived, even from a single well made ascension of this kind, the above sum is paltry enough ; dollars have been spent for single observations of far less value. The advantage of these balloons would be very great, they could be used in determining the approximate height of a dense and apparently uniform stratus or nimbus and its velocity can be very readily determined in an inexpensive way. I suggest only one method, perhaps the least expensive of any. Let two men have their watches compared very carefully or let them be stationed so that the one can see a flag at the other station. Let a flat plate of tin, two to three feet long and one foot wide, be suspended from a short edge by two cords so arranged on a circular disk that the plate may be set at any vertical angle from the meridian. Let the observers be about 1,000 or perhaps 2,000 feet apart and let the balloon be sent up, if possible, so far from the observers and to the windward, or in the direction in which the upper current is moving, that it shall have reached approximately the highest point of its ascension before it passes the first observer. The height may be readily adjusted by weighting the balloon. As the first observer sees the balloon coming, let him place the plane of his plate exactly at right angles to the path of the balloon and place his eye so that its line of sight will lie exactly in the plane, let him signal the moment the balloon passes his line of sight or note the time, and if the second observer notes the time of passage over his plate, set the same way, we shall have the data for the velocity of the balloon. If it takes one minute to go the distance between the plates, the velocity will be about seventeen feet per second, if the observers are 1,000 feet apart. It may sometimes be necessary to send up one balloon in order that the observers may get approximately in the line of motion. This simple method will do away with the more cumbersome and expensive method of observations of angles.

In studying the relations between cloud movements and isobars, I have had projected all upper cloud movements observed at all stations of the Signal Service for the month of April, 1887, for the 3 and 10 P. M. maps. These charts showed several characteristics of the highest interest. There was a well-marked and general tendency of the movement of clouds toward the east at all times when there were no well marked low or high areas near. In the latter cases there was an undoubted circulation of upper clouds precisely similar to that of the lower winds, *i. e.*, with the motion of watch hands or away from a high area, and counter-clockwise or toward a low area. Whether one or the other of these directions was taken, depended largely upon whether it was in a direction toward the east, *i. e.*, a motion away from a high area was turned slightly in a direction clockwise whenever it would bring it nearer to the regular easterly movement. There was also a slight tendency at the more southerly stations toward a motion from the S. and S. W.

One of the most tenaciously held theories of tornado formation is that it is caused by the meeting of warm southerly and cool northerly winds. Afterward it was shown clearly that tornadoes occur in the S. E. quadrant of a low area hundreds of miles from the nearest north winds. Now we are told that the cause is as follows: the warmer surface wind from the south underruns the upper current from the north, thus producing an unstable equilibrium. At first sight it might seem impossible to determine this one way or the other, but fortunately, during the occurrence of tornadoes, the upper clouds may almost invariably be seen. A careful study of these upper clouds, in connection with tornado formation, has shown, as already noted, in general, a uniform and steady current from the south or southwest exactly coinciding with the motion of the surface wind.

The other element we wish to study in connection with cloud movements is their velocity. Prof. Ferrel thinks this gradually increases as we rise in the atmosphere, but he does not give any figures showing how far up this increase goes on. This is certainly a very important matter. We can obtain the approximate velocity by the wind on Mt. Washington, but this would be up to only 6,300 feet, the height of the anemometer cups. The following method is suggested for determining an approximate relation

between these velocities. A balloon kept at 6,000 feet or even 10,000 feet altitude will move exactly with the current at that height, and its velocity can be told by observations of the places it passes over; now, if the balloon does not revolve when it moves horizontally (the motion if any is very slight) it will be possible to tell whether the clouds above are moving faster, slower, or with the balloon. Of course, the velocity can very exactly be determined by sending up balloons, which shall move horizontally after attaining a certain height, as already suggested.

Turning to the observations on Mt. Washington, I have made a very careful study of the records for the year May, 1886, to April, 1887. Great caution must be used in assuming that we have here the exact motion, either in direction or velocity of the air strata at this height; I do not think we do. It should be noted that while the sides of the mountain deflect the air upward and give too great an air motion, yet this is counterbalanced in part by the fact that in many months of the year cold and frost vitiate largely the amount of motion that really occurs; this is specially the case with average velocities. In order to obtain an approximate observation of the difference between the actual wind velocity and that recorded by the station anemometer, an instrument was placed upon a high signal tower on the summit. This was forty feet above the summit and exactly the same amount above the station anemometer. If more air passes over at the surface than some distance above, the upper instrument should give the less velocity, though it is impossible to determine at what point the true velocity could be ascertained. It should be noted that the station anemometer may be slightly affected by a sloping roof. Comparison for a single month showed that the higher anemometer gave about eight per cent. less velocity than the lower. It is probable that the only method of getting the accurate movement would be to allow toy balloons to cross over at 100 or more feet above the summit, though an approximate result could be determined by means of an iron column 100 feet long having anemometers at vertical distances of about twenty-five feet. Of course whatever deductions may be made, in regard to winds at different times, would be affected in like manner by this cause. Bearing these points in mind, we are prepared to study the wind velocity on Mt. Washing-

ton. I divided all the 365 days in the above period into three groups. (1) Days of wind where there was a well-marked low area within about 400 or 500 miles of Mt. Washington, 164 cases. (2) All cases in which there was a high area, either over or very near the station, seventy-three cases. (3) The remaining cases, which I will call "between," 128. It will be seen easily that often these cases would run into each other and it would be difficult to assign each to its proper position.

AVERAGE WIND VELOCITY ON MT. WASHINGTON DURING THE PASSAGE OF LOW AND HIGH AREAS AND ON DAYS BETWEEN.

LOW.					HIGH.			
Month.	Cases.	Mean Max.	Mean.	Velocity of Storm.		Cases.	Mean Max.	Mean.
May, . .	16	65·4	45·9	25·5		2	32·0	16·5
June, . .	12	69·0	49·2	28·5		9	26·4	13·0
July, . .	14	62·2	45·4	32·6		6	39·8	20·8
August, .	11	70·5	52·3	27·7		14	32·1	19·1
September	13	73·9	53·5	36·6		9	34·3	19·4
October,	8	62·5	46·9	29·6		11	33·0	19·2
November	16	68·1	50·0	32·2		2	62·0	41·5
December	13	77·3	58·8	35·9		5	41·6	23·2
January,	21	82·0	65·2	40·1		2	41·0	30·0
February,	16	89·8	65·0	45·7		6	56·0	35·7
March, .	11	68·8	45·0	38·0		1	60·0	45·0
April, . .	13	71·0	51·2	31·8		6	39·3	21·2
Mean, .	164	72·6	53·3	34·2		73	37·1	21·6

"BETWEEN."			
May, . .	13	41·5	23·2
June, . .	9	40·8	24·3
July, . .	11	49·3	29·2
August, .	6	37·7	22·8
September	8	61·5	41·4
October,	12	60·1	38·2
November	12	52·5	32·9
December	13	63·8	45·4
January,	8	73·0	50·4
February,	6	66·7	50·0
March, .	19	67·3	45·6
April, . .	11	64·9	45·3
Mean, .	128	57·2	37·7

MEAN RESULTS.				
	Cases.	Mean Max.	Mean.	Velocity of Storm.
Low area, . .	164	72·6	53·3	34·2
High area, . .	73	37·1	21·6	
Between, . . .	128	57·2	37·7	

I have no doubt that a more careful gleaning would tend to give higher velocities near a low area and lower velocities near a high area, so that these deductions will be safe. In the case of

the low areas near the summit, I took out on each date: (1) The direction and distance of the low area from the summit; (2) The maximum velocity of the wind during the twenty-four hours, with its direction; (3) The mean velocity of the wind for twenty-four hours; and, (4) The mean velocity of the low area as it approached and moved away from the summit. For the high area I took out only the maximum velocity in twenty-four hours, together with the mean velocity for the same time. The latter method was also followed in the "between" cases. A summary of the results of these observations is given in the foregoing table:

We see from this table that the velocity is greatly increased when there is a low area near the summit, and the velocity of the wind far exceeds that of the progressive motion of the storm. The latter deduction is very remarkable, and is directly opposite to the theoretical results obtained by Prof. Ferrel. It would seem as though either the cause of the progressive motion of the storm centre is distinct from the motion of the general current, or else that its seat is considerably below the summit of Mount Washington. There is one consideration in favor of the first supposition, in the fact that the fluctuations of pressure at the highest stations, such as Pike's Peak and Mount Washington, are nearly the same in amount as at sea level.

Since Prof. Loomis has determined that the "power" of the storm is generally below 6,000 feet, and since balloon observations rarely show rain much above that point, it would seem as though the idea that this "power" may be at a height of 16,400 feet, and also that the progressive motion of a storm is much greater than that of the atmosphere, even up to a considerable altitude, would need to be much modified. It is certain that the theoretical determination of twenty-six miles per hour for the current at this height cannot be accepted.

Conclusions.—(1) The upper currents of the atmosphere, while having a general motion to the eastward, at the same time have a motion about high and low areas similar to that of the surface winds.

(2) The upper cirrus clouds, in general, have a motion similar to that of the currents at about 5,000 feet elevation.

(3) The velocity of the currents at about 6,000 feet is less than half at a high area that it is at a low area. This may be an explanation of the fact that the maximum daily winds at mountain stations come at about sunrise and the minimum at the hottest part of the day. May not the heat after the middle of the day expand the air sufficiently to cause a rise in pressure somewhat similar to a high area, and hence the diminution in the wind velocity?

(4) If the progressive motion of storms is dependent on that of the general upper air currents, then the motion of the lower clouds, or at least of those below 6,000 feet, must indicate much more clearly the direction of the storm than the upper clouds.

(5) It would seem possible to determine quite closely the path of an advancing low area, if we know the height and direction of the clouds in front of it.

(6) It seems probable, from the enormous increase of velocity of the upper currents in the neighborhood of a low area, that this rapid increase in velocity will account, if not entirely, still largely, for the intensity of the storm.

(7) It was determined in 1884 that thunder-storms, in the southeast quadrant of a low area and often 600 miles from its centre, frequently attained a velocity double that of the accompanying low area. That they gained upon the low area, during the day hours, to die out at night and begin again at a point a little east of the point where they began the day before, perhaps about as far east of that point as the low area had moved toward the east, and from thence repeat the movements of the previous day. I throw out, as a suggestion, that possibly these storms rise to a height somewhat in excess of that of the "power" of the low area, and hence, having reached a current moving more rapidly than that of the low area, they are transported much more rapidly. This would be a plausible explanation if we consider that the progressive motion of the flow area is caused by that of the current wherein its "power" is seated.

We may well conclude finally that herein is presented a most promising field of research for those who would be weatherwise.

GENERAL THEORY OF JOINTED BOW GIRDERS.

By E. A. Werner, C.E.

(*Continued from Vol. cxxv, page 499.*)

I turn now to the strains themselves:

CHORD STRAINS.

$$U_m = \left(\frac{M}{h}\right)_m \pm H.$$

The chord strains always consist of the strains of the moments and when the chord takes up the thrust, also of the thrust.

As W is the increment of the chord strains from point to point, U will increase or decrease as long as W does not change its sign and will have a maximum or minimum with $W = o$, while U itself can be either positive or negative.

Hence, in constructing the curve of U, in using U as y, we shall have in any girder the following figure for the chord strains near the point $W = o$, and we see at once that with the change of the sign of W is connected a change in the direction of the action of U, in consequence of the maximum of U corresponding to $W = o$. We deduct thus the

Rule.—A change of the sign of W reverses every time the direction or the sense (*not the sign*) of the chord strains U.

Rule.—The chord strains have relative maxima and minima in those points on the right and left, of which W is of different sign.

In the difference $\triangle U = U_m - U_{m-1}$ each factor can be of any sign, so that with a positive and negative moment the action of W still can be positive. Hence, we have the

Rule.—The sign of U is independent of the sign of W.

From $W = U_m - U_{m-1}$ follows furthermore:

Rule.—If *no* tie is acting in a panel point, the horizontal component of the chord strains at the right and left of the panel point have the same value.

TIE STRAINS.

We have:

$$W_m = \left(\frac{M}{h}\right)_m - \left(\frac{M}{h}\right)_{m-1} = U_m - U_{m-1} = \triangle U.$$

From it follows directly:

Rule.—The *horizontal component* of the *tie strains* always is *equal* to the *difference of the horizontal components* of *the chord strains* at the right and left of the panel point.

From this rule we deduct then the very important

Rule.—The tie strains are independent of the thrust of the structure.

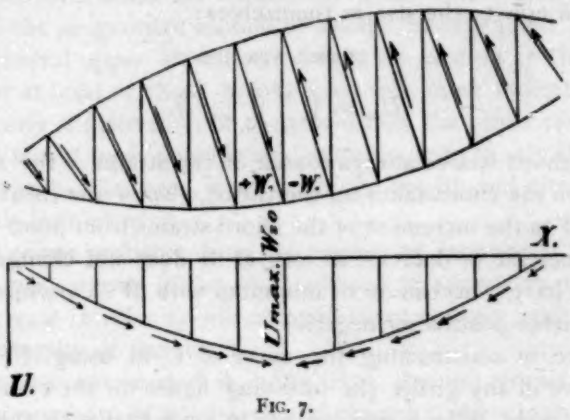


FIG. 7.

We know that a change of the sign of W implicates every time a change in the direction of the chord strains. We have thus:

Rule.—The sign of W indicates the *direction* (not the sign) of the action of the chord strains and: (see *Fig.* 7.)

Rule.—If the same kind of ties shall be used throughout the structure, it is necessary to reverse each time, that W changes its sign, the direction of the tie.

It remains now to define the position of the loads creating the

MAXIMAL AND MINIMAL STRESSES IN THE MEMBERS OF THE TRUSS.

Considering to that effect the expressions of D, E, B, W, U, P, we see *that all these expressions are simply algebraical sums of the moments and the thrust.* Hence in substituting M and H expressed in G_1 G_2 G_3 in the equations of the above forces, *all these forces will be of the same form:*

$$\text{Strain} = a\ G_1 g_1 + b\ G_2 + c\ G_3 (l - g_3)$$

herein will be:

a, b, c the algebraical sums of the coefficient a b c of each single

factor composing the strain, while the action of $G_1\ G_2\ G_3$ will be regulated by the rule of the shearing forces, which gives the action of algebraical sums of moments.

As the coefficients $a\ b\ c$ as well as $G_1\ G_2\ G_3$ have exactly the same signification in the above general equation of the strains as in the equation of the moments of the external forces, all the results obtained for the last ones, can be directly transferred to the above general equation of the strains and especially also the way in which the maximal and minimal value of the moments is found. The rule given there is thus quite general and reads:

"*To find the maximal value of any strain in the member of a hinged bow girder, calculate or construct a b c, in adding or subtracting the corresponding a b c of each single factor composing the strain, calculate also the corresponding maximum line of G_2 from $b = o$ and fill those parts of the structure corresponding to positive values of a b c with loads, in using the greatest possible values of $G_1\ G_2\ G_3$ and vice versa for the minimal value of the strain.*"

The application of this rule will present no difficulty as soon as I shall have explained the way in which the greatest possible value of $G_1\ G_2\ G_3$ can be found.

As I have shown with the external forces, the ordinates y and f are parting lines of the forces, that is: lines to the right and left of which the action of the forces is different, the ordinate of the line of maximum is the parting line of the positive and negative increments of the loads connected with the coefficient b, whatever be the way of loading or the numeric value of the loads.

These lines are in fact absolute divisions. If a and c are of different sign, any load producing a positive action in the part a, will produce a negative action in the part c. Nevertheless, as the total value of the strains is the algebraical sum of mostly three members, this total value can become greater, when, in filling the girder with loads, these parting lines are somewhat transgressed. Although producing in *one* part unfavorable actions of the loads, the special position of the loads in the other part, can produce so much favorable action, that the unfavorable action in the one part is more than counterbalanced and the total value of the strain greater than if the parting line had not been transgressed.

I can explain this in the easiest way with an example, using an ordinary square truss, of which the positions of the loads inducing

the maximal and minimal values of the stains are conversant to everybody.

If we make:

$$y = o$$

$$G_3 = o$$

in the equations, it follows:

$$m_m = \textit{moments} = G_1 g_1 \left(1 - \frac{x}{l}\right)_m + G_2 x \left(1 - \frac{g_2}{l}\right)_m$$

$$V_m = \textit{shearing forces} = -\left(\frac{G_1 g_1}{l}\right)_m + G_2 \left(1 - \frac{g_2}{l}\right)_m$$

$$W_m = \left(\frac{M}{h}\right)_m - \left(\frac{M}{h}\right)_{m-1}$$

For an ordinary square beam now we have:

$$h_m = h_{m+1}$$

and

$$W_m = \frac{M_m - M_{m-1}}{h_m}$$

or

$$W_m = \frac{h_m}{\Delta x_m} = N_m \sin a_m = V_m$$

or

$$N_m \sin a_m = -\left(\frac{G_1 g_1}{l}\right)_m + G_2 \left(1 - \frac{g_2}{l}\right)_m$$

or the strains in the ties become a maximum with the shearing forces.

Now,

$$b = o$$

gives:

$$g_2 = w_2 = l$$

Hence the strain in the ties of a square beam is a maximum, when $G_1 g_1$ the negative part is empty and G_2, that is that part from the end of the tie, to the right end of the structure is filled with loads.

Nevertheless it is known, that it will be necessary to shift the rollers of the engine over the parting line of $G_1 g_1$, in the negative

part of G_1, in order to reach the absolute maximum of the strains, in fact to produce some negative strains in order to bring the heaviest loads on the second part of the girder. The increase of G_2 the positive strain is greater than the increase of G_1 and the total value of W greater, than if the rollers had not transgressed the parting line.

How far the limits must be trespassed in each case, depends of course upon the way of loading, but the same means, which give the positions of the loads inducing the maximal and minimal values of the strains in an ordinary beam, will also prove efficient in case of the bow and I think the above example has sufficiently illustrated the way to be followed.

With this the above rule for defining the positions of the loads creating the maximal and minimal values of any strain in the bow structure can be applied without difficulty. But the application can be made materially much easier by means of special arrangements, which I will now show. I begin with the:

STRAINS IN THE CHORDS.

We have:

$$U_m = a_u G_1 g_1 + b_u G_2 + c_u G_3 (l - g_3)$$

$$U_m = \left(\frac{M}{h}\right)_m \pm H$$

The equation includes three cases:

First, $H = o$; second $\left(\frac{M}{h}\right)_m = o$, and third, H and M not zero.

(1) $H = o$ *or the chords take up no thrust.* Then $U_m = \left(\frac{M}{h}\right)_m$ becomes a simple function of M, and has its maximal and minimal values with the positions of the loads inducing the maximal and minimal values of M.

(2) $M = o$ *or the chords take up the thrust only.* Then $U_m = H$ becomes a simple function of H and has its maximal and minimal values with the maximal and minimal values of the thrust.

I will again mind the reader to be very careful in calculating U, as the case that M becomes zero commands every time its own,

quite different position of the loads for the maximal and minimal values of U.

(3) *The chord takes up the combined action of the moments and the thrust.*

In this case, the coefficients a b c of U are still so simple that the positions of the loads inducing the maximal and minimal values of U easily can be constructed graphically

If we consider to that effect the equation:

$$h_m U_m = G_1 g_1 \left(1 - \frac{2fx + l(y \pm h)}{2fl}\right) +$$

$$+ G_2 \left(x - g_2 \frac{2fx + l(y \pm h)}{2fl}\right) + G_3 (l - g_3) \left(\frac{2fx - l(y \pm h)}{2fl}\right)$$

which is obtained, when the coefficients of H are added or subtracted from the coefficients of M, we see that this equation is exactly the same as that of the moments:

$$M_m = G_1 g_1 \left(1 - \frac{2fx + ly}{2fl}\right) + G_2 \left(x - g_2 \frac{2fx + ly}{2fl}\right) +$$

$$+ (G_3 (l - g_3) \frac{2fx - ly}{2fl}$$

when we use in the latter in place of y, the ordinate $(y \pm h)$.

As h is the depth of the stiffening truss in the point x_m y_m nothing is easier than to draw the curve corresponding to $(y \pm h)$. I shall call this line

"THE DIRECTRIX OF U."

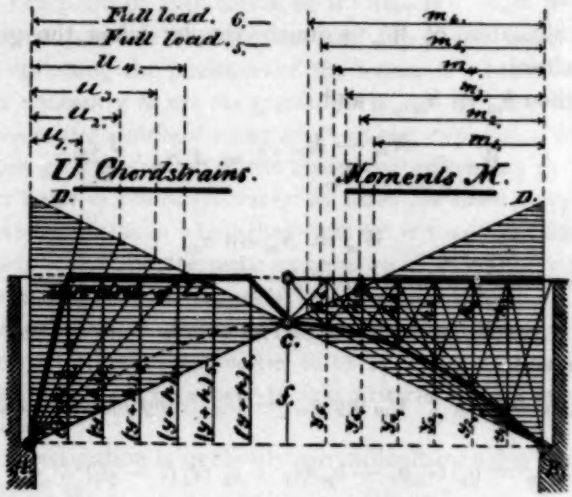
The directrix of U is to U exactly the same what the line of thrust is to the moments and the deductions made for M can directly be applied to U.

Hence to find the maximum line of G_2 for U or $g_m = u_m$ draw the directrix of U in adding or substracting the height of the stiffening structure from the corresponding y of the line of thrust, and draw the deciding triangle. The abscissa of the intersection of the two lines $D\,C$ and $A\,(y \pm h)$ will then locate the line of maximum of G_2 or

$$u_m = g_m = \frac{2fl\,x}{2fx + l(y \pm h)} \qquad (IV^a)$$

For the rest we know from M that, when the directrix of U lies *outside* the deciding triangle, the maximum of U is reached with full loaded girder.

Fig. 8.



The directrix will be used to advantage for calculating $a_u\ b_u\ c_u$, the coefficients of U, which are needed for defining the maximal and minimal values of P and W.

The coefficients $a_u\ b_u\ c_u$ can also be calculated in adding (or subtracting) $a\ b\ c$ of $H = \dfrac{1}{2f}$ to the values of $a\ b\ c$ corresponding to $\left(\dfrac{M}{h}\right)$.

STRAINS IN THE TIES.

We have:

$$W_m = U_m - U_{m-1} = \left(\frac{M}{h}\right)_m - \left(\frac{M}{h}\right)_{m-1}$$

or

$$W_m = a_w\ G_1\ g_1 + b_w\ G_2 + c_w\ G_3\ (l - g_3)$$

The coefficients $a_w\ b_w\ c_w$ are calculated in subtracting either the values of $a\ b\ c$ corresponding to $\left(\dfrac{M}{h}\right)$ or U. In putting then $b = o$, the value of w_m, the maximum line of G_2, is easily found.

In the first panel, and the panel before the top joint, $\left(\frac{M}{h}\right)_o$ or $\left(\frac{M}{h}\right)_n$ is zero, and hence W a simple function of M.

The division of G_1 is thus for W_1 and W_2 the same; also for W_{n-1} and W_n.

The calculation of W_m is much simpler when the girder has parallel chords.

It is then $h_m = h_{m+1}$, and

$$W_m = \frac{M_m - M_{m-1}}{h_m} = \Delta S_m \cdot \frac{\Delta x_m}{h_m}$$

or

$$W_m = N_m \sin \alpha_m$$

and W is simply a function of S.

STRAINS IN THE POSTS.

We have:

$$P_m = W_m \operatorname{tng} \alpha_m + U_m \operatorname{tng} \rho_m - U_{m-1} \operatorname{tng} \rho_{m-1} \pm E_m \mp g_m$$

or

$$P_m = a_p G_1 g_1 + b_p G_2 + c_p G_3 (l - g_3) \mp g_m$$

The calculation of a_p b_p c_p is made in adding together the respective coefficients a b c of W_m, U_m, U_{m-1} and E_m.

P is the most intricate strain. Its expression differs in two regards from the expression of the other forces. First in containing the member $\mp g_m$, and, second, in being often not reversible for maximum and minimum.

The first property, the member $\pm g_m$, would greatly complicate the definition of the positions of the loads inducing the maximal and minimal values of P, if it could not be eliminated. Luckily *two* expressions, one from the upper and one from the lower chord, for one and the same P are at our disposal. The first step to find the positions of the loads inducing the maximal and minimal values of P is thus:

RULE.—*Always select that chord of the stiffening structure, which takes up no moving loads, for defining the positions of the loads corresponding to the maximal and minimal values of* P.

The member $\pm g$, expresses then only the action of its own weight, or becomes a constant, without influence on the maximal and minimal values of P.

The second property named above, that the equations of P not always are reversible, or that from one and the same equation not always can be deducted the position of the loads inducing the maximal and minimal values of P, is the consequence of the action of W. The point of application of W' and W'', or of N' and N'' in the same panel is the bottom and top of the post. Hence, when in reversing the positions of the loads, W'' becomes acting, it will be necessary *to use the special form for W'' in order to find the maximal and minimal value of P*, as the expression of P with W' cannot give the action of the forces corresponding to W''. On the other hand, *when in reversing the loads the same tie remains in action*—as for instance when the same tie is used for compression and tension—one and the same expression of P will give the position of the loads for the maximal and minimal values.

Still another value of P must be investigated. That corresponding to the action of *two* or *no* tie, or to $W = o$.

To that effect it is necessary to find first the points in which W becomes zero.

This investigation is generally not difficult by using the general equations of W.

But only those points, for which W is of different sign to the right and left of the point of application, correspond to a maximum or minimum of U, as only in these points the increment of U or W passes from the positive to the negative.

These points selected, the numeric values of P must be calculated and in comparing these values with the other values of P corresponding to the action of one tie, the absolute maximal and minimal values of P can finally be pointed out.

D, E, B, STRAINS IN THE MEMBERS OF THE BOW STRUT, THE SUSPENSION RODS AND THE SUSPENDED ABUTMENT.

All these strains are simply functions of the thrust, and reach thus their maximal and minimal values, with the maximal and minimal values of H.

Herewith the second part of our problem, to wit:

"To determine the positions of the loads creating the maximal and minimal values of the strains in the members of the bow structure, and the rules governing these positions of the loads—" is now solved and I will, as conclusion, resume here the

COURSE OF THE CALCULATION.

Calculate:

(1) *The data for calculation* as: the ordinates of the form of the line of thrust, α, β, γ, μ, etc.

(2) *The coefficients*

(*a*) by means of *the deciding triangle* and the *line of thrust for*

$$\left(\frac{M}{h}\right)$$

$$\frac{\zeta' - y}{2fh}, \quad \frac{\zeta + y}{2fh}, \quad \frac{\zeta - y}{2fh},$$

(*b*) by means of the *deciding triangle* and the *directrix of* U, for U

$$\frac{\zeta' - y}{2fh}, \quad \frac{\zeta + y}{2fh}, \quad \frac{\zeta - y}{2fh},$$

Check. The values of the above coefficients are different by the value of $a\ b\ c$ of $H = \frac{1}{2f}$

(*c*) by simply *subtracting* either the coefficients of

$$\left(\frac{M}{h}\right) \text{ or of } U,$$

the *coefficients* of W.

Check. The values must be the same whether U or $\left(\frac{M}{h}\right)$ is used.

(3) *Form the general equations of* $\left(\frac{M}{h}\right)$ U, W, construct or calculate the corresponding lines of maximum of G_2 with $b = o$, select accordingly the positions of the loads inducing the maximal and minimal values of the above strains, and calculate their numeric values.

(4) *Calculate* for $\left(\frac{M}{h}\right)$ and U the *course of the ties* corresponding to the positions of the loads inducing the maximal and minimal values of these strains, and determine the direction of U. The direction fixed, calculate the maximal and minimal values of A and

T, and also by means of W the maximal and minimal values of N or N' and N''.

(5) *Find out* by means of *the general equations* of W the *points in which W passes through zero*, or the points to the right and left of which W is of different sign.

(6) *Calculate* by *summing up* algebraically the corresponding coefficients of the composing forces the *coefficients of* P, when:

(1) The ties W'
(2) The ties W''
(3) *Two* ties or *no* ties, or $W = o$

} are acting.

Put up the corresponding general equations of P and calculate the maximum lines of G_2. Construct the corresponding positions of the loads inducing the maximal and minimal values of P, and calculate finally their numeric values.

Check. The values of the strains of P must be the same, whether calculated from the top or the bottom chord. *That chord which takes up no moving loads must be used without exception for defining the coefficients of P and its general equations.*

(7) *Calculate* the values of D, E, B directly from H.

I shall now show the application of these rules in an example.

(*To be continued.*)

On SOME EARLY FORMS of ELECTRIC FURNACES.

No. 8. WERDERMANN'S ELECTRIC FURNACES.

By Prof. Edwin J. Houston.

Richard Werdermann, well-known to the scientific world in connection with his semi-incandescent electric lighting system, has made a number of ingenious applications of electrical currents to metallurgical purposes, some of which may properly be ranked under the general heading of electric furnaces.

The earliest of Werdermann's electric furnaces is described in Brit. Patent No. 474, of 1873, for an "Improved Method of Reducing and Purifying Metals," and dated February 10th, 1873.

Werdermann's process does not differ materially from that practiced by other inventors. The ore to be treated is first crushed and then raised by ordinary heat up to a red heat, when the metal is extracted by sending through it an electric current, led into and through the heated mass by terminal electrodes of carbon, platinum, or other refractory substances that are conductors of electricity. The electric source proposed by Werdermann was either a voltaic battery or a dynamo-electric machine.

Werdermann proposed to employ his process of electric reduction either in connection with or independently of the reducing action of carbonaceous matter.

The following description of his process is taken from the specification of the above mentioned British patent, viz:

"My invention relates to an improved mode of applying electric currents in order to reduce metals directly from their ores with or without the ordinary chemical action of carbonaceous matter, and in purifying and refining at the same time and by the same process the metal during its reduction from the ore.

"The ores, that is to say, oxides, sulphides, carbonates, or other combinations in which the metals exist in nature are first crushed, and then heated in a suitable furnace or retort.

"After the whole charge is raised to a red heat, two pieces of carbon or platinum or some other suitable material which conducts electricity, are plunged in the crushed ore. These two pieces are

connected by a platinum or other suitable wires or ribbons with the two poles of a galvanic battery or magneto-electric machine."

Werdermann mentions the necessity for properly regulating the electro-motive force and current employed. He describes the applicability of the current to the operation of *electric puddling*, and states the saving in time thereby effected.

"By regulating in a suitable manner the electro-motive force and the intensity of the electric current, and stopping it at the proper moment, cast iron, wrought iron, or steel can be produced directly from the furnace without any intermediate operations. This puddling by means of an electric current will occupy from ten to fifteen minutes only, instead of several hours as in the ordinary puddling by hand labor or machinery, and consequently a great saving of time will be effected."

The application of electricity to the puddling furnace would appear to possess great promise, and it is singular that the process has not as yet been carried into actual extended use. It is probable that a difficulty has been found to arise as regards the proper regulation of the current, and the quality of the wrought iron produced, should the process be stopped either too soon, or not soon enough.

In Brit. Patent No. 1933, of 1873, Werdermann describes a process for the production of aluminium in which, reversing the order of sequence, electricity is first employed, and heat afterwards. This process consists, briefly, in acting electrolytically on common salt and thus reducing it to a sub-chloride Na_2Cl, or Na_4Cl_2 (?) This chloride is then reduced to a powder and mixed with cryolite, or chloride of aluminium, or with double chloride of aluminium and sodium in sufficient quantity for the reduction of the aluminium. The mixture, with or without suitable fluxes, is then to be heated to redness in a reverberatory furnace, when, it is claimed, the reduction quickly takes place. The practicability of this process must be considered very doubtful.

In 1874, Werdermann invented a process for the cutting of rock by the heat of the voltaic arc. This process, though affording an excellent illustration of the application of powerful electric currents, can hardly be ranked under the head of electric furnaces, unless it may be regarded as a species of blast or reverberatory furnace for the fusion of refractory substances.

Werdermann applied his invention by causing the electric current to pass between two carbon sticks or electrodes placed parallel to each other. The arc was formed at their extremity by causing the current to pass up one of the carbons and down the other.

It will be noticed that Werdermann's invention of the electric blow-pipe in reality anticipates the invention of the Jablochkoff electric candle, in which two parallel carbon electrodes are used, as in Werdermann's apparatus, for the production of light instead of heat.

Werdermann patented his invention in England in patent No. 1,438, of 1874, under the title of "An improved method of cutting rock or stone and other hard substances, applicable for tunnelling, mining, quarrying, shaping, or dressing stone, and for other like operations." The patent is dated April 24, 1874.

The following description is taken from the specification of the other patent:

"The said invention consists mainly in the application of intense heat to the rock or other substances to be cut, crushed, or perforated, and is carried into practice in the following manner: On a rod or stem of cast iron or other suitable material is fixed a set of powerful air or steam blow-pipes at such distances apart as to cover when in operation the entire surface of the rock to be cut or penetrated. * * *

"When the rock is very hard, as porphyry, granite, gneiss, and the like, I prefer to use an electric blow-pipe in the following manner: The carbons of the electric light are fixed on a suitable handle provided with screws to regulate by hand the distance of the carbon points. At equal distances from the carbon points are arranged the two poles of a powerful electro-magnet. As soon as the light is produced, and the electro-magnet set in action, the voltaic arc is repelled and pointed like the flame of the blow-pipe. The same effect is obtained in blowing through the voltaic arc between the two carbon points a powerful current of air or steam or other suitable vapor or gas.

"The heat obtained by such an electric blow-pipe is so intense that the hardest gravel not only calcines but fuses in a few seconds."

The ingenious application of an electro-magnet for the purpose of directing the arc against the surface to be acted on, is similar to the use of the coil placed around the electric crucible of Siemens

for preventing the arc from playing against the sides of the crucible, and directing it on the substance that is to be fused.

In Brit. Patent No. 4,805, of 1876, dated June 12, 1877, Werdermann patented the use of parallel carbons, suitably insulated from each other, for the production of the electric light.

CENTRAL HIGH SCHOOL,
PHILADELPHIA, April 7, 1888.

OBITUARY.

JAMES CURTIS BOOTH.

In preparing a minute of the death of Prof. JAMES CURTIS BOOTH, your committee feels that it is not inappropriate to quote the following concise and authentic biography from the illustrated history of the United States Mint, 1885 (published by G. G. Evans, Philadelphia):

"JAMES CURTIS BOOTH, melter and refiner, United States Mint, Philadelphia, was born in Philadelphia, 1810; educated in the same place and was graduated from the University of Pennsylvania, 1829, after-study and field practice in the Rensselaer School, at Troy, N. Y., in 1831 and '32, under the late Prof. A. Eaton.

"Mr. BOOTH derived his knowledge of practical chemistry in Germany in 1833, '34 and '35, in the laboratories of Profs. F. Wohler and G. Magnus, and in visiting accessible manufacturing establishments in Germany and England.

"The late Prof. J. F. Frazer and Mr. BOOTH were the two assistants on the Geological Survey of Pennsylvania in its first year, 1836. Mr. BOOTH next had charge of the Geological Survey of Delaware, in 1837 and '38 (being assisted by Prof. J. F. Frazer), and published his report of the Survey in 1839 and '40.

"Mr. BOOTH, observing the great necessity for a knowledge of applied chemistry in his native place, opened a laboratory for teaching the same by chemical analysis and by operative work in 1836, and the laboratory then established has been continued successfully to the present time by Mr. BOOTH, in association with Mr. T. H. Garrett and Mr. A. Blair. Having the same object in view, Mr. BOOTH lectured at the FRANKLIN INSTITUTE for nine (9) successive winters, there giving three full courses of lectures upon

chemistry applied to the arts, each course of three winters' duration, 1836–45. In 1843, Mr. BOOTH published the 'Encyclopædia of Chemistry,' he being the author of the majority of the articles contained in it, with valuable contributions by Prof. R. S. McCullough and others. It proved and continues to be a substantial adjunct to the study of chemistry."

It should be borne in mind that when Prof. BOOTH delivered lectures upon chemistry at the FRANKLIN INSTITUTE, the facilities for scientific and chemical instruction were very limited as compared with those of the present time.

The system of public education which supplanted the "poor schools" was upon trial, and the FRANKLIN INSTITUTE furnished from among its members the promoters of popular education, and was in itself an important and conspicuous participant in the work of diffusing useful knowledge.

Under these conditions, the services rendered by Prof. BOOTH deserve to be ever remembered. The classes instructed are well represented among the enterprising and successful professional and business men of the present day.

The lectures of Profs. J. F. Frazer, JAMES CURTIS BOOTH, J. C. Cresson, W. R. Johnson and Dr. J. K. Mitchell gave an enduring character to the instruction of this INSTITUTE, which can never be forgotten.

The Director and officers of the Mint unsuccessfully solicited the appointment of Prof. BOOTH as melter and refiner in 1838 and '40, but in 1849 Prof. BOOTH was appointed by President Zachary Taylor, and continued in the same position until his resignation in 1887, which was made necessary by the infirmities of advancing years.

Soon after Prof. BOOTH took charge of the Melting Department, the enormous influx of gold from California taxed the resources of the parent mint in Philadelphia to its utmost capacity, and necessitated a reorganization of the former business methods.

Prof. BOOTH proved equal to the emergency and devised methods of meeting the unexpected demands upon his department.

The present form of wind furnace used in melting gold and silver was mainly his design. The improvement over older furnaces consisting in the sliding doors and in the interior configuration which made his furnaces better adapted to the work than those of previous melters and refiners.

The mathematical formulæ for quickly making up the melts for coin ingots of standard fineness from miscellaneous deposits varying greatly in weight and fineness were worked out by Prof. BOOTH, and greatly facilitated the routine of business. After the decline of the production of gold, the discoveries of silver in Colorado and other Western states and territories followed, and notwithstanding the establishment of branch mints and assay offices in the West for the receipt of bullion, the bulk of the precious metal found its way to the Philadelphia Mint. The return to specie payments and the passage of the "Bland Silver Bill" in 1878 again resulted in an enormous and sudden demand upon the Mint, so that of late years the value of the precious metals operated upon in the melting department has averaged more than $50,000,000 per annum.

This brief statement will suffice to show the vast responsibility resting upon Prof. BOOTH, and the mental anxiety consequent thereupon, coupled with earnest desire to faithfully perform the onerous duties devolving upon him, was the immediate cause of his long illness which prompted him to tender his resignation some months before his decease, to take effect upon the appointment of a successor.

Prof. BOOTH was a gentleman of courteous manner, genial presence and of singular modesty. As a public officer he was a shining example in these respects, and the fact that throughout all of the political changes of administration he retained his highly responsible position for nearly forty years, and this with eminent satisfaction to all, is alike creditable to himself and to the Government.

S. LLOYD WIEGAND, *Chairman*,
ALEX. E. OUTERBRIDGE, JR.,
CHARLES M. CRESSON, M.D.

PHILADELPHIA, *April 17, 1888.*

RACHEL L. BODLEY.

By the death of Prof. RACHEL L. BODLEY, M.D., the FRANKLIN INSTITUTE JOURNAL has lost the first on the list and among the most highly valued of its collaborators. Miss BODLEY lived at an

important epoch in the history of the evolution of woman's equal rights, and filled an important post in the transition stage of this question. It is not intended at this time to do more than pay the well-deserved tribute of a publicly-expressed regret to the memory of one who, while so essentially a woman, was at the same time a leader in that obviously just movement which has for its goal equal rights, equal privileges, equal facilities for learning and practicing trades and professions, and equal pay for man and for woman. It is unfortunate that the great victory for justice and magnanimity achieved in the Philadelphia County Medical Society, by the election for the first time of a woman to its membership, came but a few days too late to cheer RACHEL BODLEY, with the first symptom of a change which she, by her spotless life and earnest work, has done much to bring about. It is not the Claflins and the shriekers who can be credited with the advance of woman towards the great office that she is ultimately destined to fill, but the pure, the industrious, and the pertinacious workers who know enough of the inertia of ignorance, of prejudice and of injustice in the world to bide their time, to let the confining bark of error burst from the swelling sap within, rather than hew it off by violence. It is an instance of how much more dignified patience can accomplish than petulant complaint, that RACHEL BODLEY, who never menaced society with the consequences of neglecting her political rights, was elected one of the vice-presidents of the great convention of chemists, assembled in 1874, at the grave of Priestley, in Northumberland, Pa., while many of her sisters, who strove zealously, but not wisely, for lesser honors, failed to reach them. That they may succeed, and that before long, is the earnest hope of the writer. Their success will be the most fitting monument to the noble women who knew how to strive for a great and righteous cause; among whom none better deserved this loving remembrance than RACHEL L. BODLEY.

PERSIFOR FRAZER.

REPORTS OF THE COMMITTEE ON SCIENCE AND THE ARTS.

THE HYATT PURE WATER SYSTEM.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, December 1, 1887.

The Committee of the Chemical Section, acting as a Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to which was referred for examination

"THE HYATT PURE WATER SYSTEM,"

Report as follows: In our opinion, a pure water supply is a matter of the greatest importance, and any useful device which has this for its object, not only demands the attention of the INSTITUTE, but, if it accomplishes its design, should also receive such encouragement and support as can be furnished through the recommendation of the FRANKLIN INSTITUTE.

Through the kindness of authorized agents, one of the filters of the Hyatt Company was erected in the Hall of the INSTITUTE, where it satisfactorily performed its work in the presence of the Committee.

This system, invented and patented by Mr. Isaiah Smith Hyatt, of Morristown, N. J., has for its object the clarifying and purifying of water by first coagulating the impurities and afterwards filtering it.

It will be noticed that the invention is founded upon two distinct principles; for it is well known that the purification of water, by filtration only, has proved to be impracticable on a large scale.

The extremely fine silt held in suspension in natural water cannot be retained by any filter where large volumes are operated upon. To overcome this difficulty, Mr. Hyatt's invention is directed.

The filter is simply a body of ordinary sea-sand, supported on a perforated false bottom, the whole being enclosed in a wrought-iron cylindrical vessel.

The size of the filter is in proportion to the quantity of water handled. The smallest size on the company's schedule is ten (10) inches in diameter by three (3) feet high, capacity being two

thousand (2,000) gallons per twenty-four (24) hours; the largest size is ten (10) feet in diameter, thirteen (13) feet high, capacity three hundred and twenty-five thousand (325,000) gallons per twenty-four (24) hours. The above represents one filter only (in each case), but any number can be connected and run as one.

The announcement of the company contemplates the purification of the water supplies of cities.

The filter is connected with the supply pipe in such a manner that a by-pass is formed around the filter; or, in other words, it is so arranged that the filter may be disconnected without disturbing the flow of water through the main pipe.

A small portion of the muddy water to be treated, not more than a fraction of one per cent. of the total volume, goes through an attachment to the main filter, containing lumps of alum. A minute amount of alum is thus dissolved and passes into the filter, where it is mixed with the main body of water; the quantity of alum used being less than one grain per gallon of water. The suspended clay and other earthy matter which is of a basic nature, has the effect of precipitating the alumina of the alum, causing it to separate all through the water in the form of gelatinous flocks. These minute particles bring together or coagulate the finely suspended matter, converting it into such a form that the filter will easily and completely remove it. The supply of water to this coagulator is governed by a valve regulated by a scale, each division of which corresponds to a given quantity of alum dissolved. In consequence of this action, the minute amount of alum employed is entirely destroyed, as such, and is removed from solution, the fine silt which could not otherwise be removed by filtration is converted into such a form as to be easily removable, and the resulting filtered water is perfectly bright and clear, no matter how dirty or muddy it may have been previously.

For the purpose of cleaning the filter bed, provision is made by which the current of water can be reversed, and the accumulation of dirt, etc., is removed through a special discharge pipe. The following prominent features of this system present themselves:

(1) The ease with which the filter is cleaned, it requiring only a few minutes, and involving no extra manipulation or disturbing of the filtering material, but simply the opening of certain valves.

(2) The rapidity with which the filter works, for with filters

destitute of a coagulating substance, the operation depends upon the closeness of the particles of the filter bed, and the water passes through very slowly. In the Hyatt filter, the water runs through in a large stream, the bright clear water running out producing a marked contrast with the dirty water entering the apparatus.

(3) The ingenious method adopted to coagulate the impurities, which plays an important part in the operation of the filter, and the decomposition of the alum, which is introduced in such infinitesimal quantities, forming a compound which remains on the filter and which, if it should, by any accident, be mechanically carried through the filter, would be without any effect upon the water. Certain chemical analyses, however, indicate that weighable quantities of the body formed (which is the hydrate of alumina) are not so carried over.

(4) The success of the filter, as proved by the favorable reports we have received from paper manufacturers and those using the filter for domestic purposes, who have, after constant use for a period of three (3) years or more, been convinced that these filters answer admirably the design of their invention.

(5.) The adaptability of this system to the purification of the water supply of cities; and,

WHEREAS, We are convinced by the above considerations, as well as by the theory of the system, of the utility of the same, we respectfully recommend that Isaiah Smith Hyatt be awarded "THE JOHN SCOTT LEGACY PREMIUM AND MEDAL," for this ingenious and practical invention.

H. WILEY THOMAS,
H. PEMBERTON, JR.,
E. H. KEISER.

Adopted January 4, 1888.

WM. D. MARKS, *Chairman.*

I certify that the above is a true copy from the records.

WM. H. WAHL, *Secretary.*

CLAMER'S PROCESS OF CLEANSING AND COATING METAL SURFACES.

[No. 1385.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, March 1, 1888.

The Committee on Science and the Arts, constituted by the

FRANKLIN INSTITUTE of the State of Pennsylvania, to which was referred for examination

"THE AJAX METAL COMPANY'S PROCESS OF CLEANSING, PREPARING AND COATING METAL SURFACES,"

Respectfully reports: that the process in question is the subject of letters-patent of the United States granted to Francis J. Clamer, of Philadelphia, as follows:

No. 283,077, dated August 14, 1883, for a process of treating lead to impart to it the property of adhering to other metals; and No. 363,593, dated May 24, 1887, for a process of cleansing, preparing and coating metal plates and other metal surfaces. Concisely stated, the object which Mr. Clamer has sought to accomplish in the two inventions above named, is to treat iron and steel articles by a process of chemical cleansing which shall remove all oxide and other impurities from the surfaces of the same, leaving these surfaces in such a condition as to adapt them to receive most readily a firmly adherent and smooth coating of lead. As important to the successful operation of the process, the inventor claims that the addition of slight quantities, not exceeding a small fraction of one per cent., of arsenic and phosphorus, imparts to the lead certain qualities which adapt it to yield a better and smoother coating than it is possible to obtain by other methods in use.

The process of preparing the metal for the coating is substantially as follows:

The articles of wrought or cast iron or steel are first pickled in the usual way by immersing them in a bath of dilute sulphuric acid, kept heated by the aid of a steam coil. They are then rinsed thoroughly in fresh water to remove the adhering acid. The articles are then removed and immersed in a cleansing bath of cyanide of potassium. An electric current, generated by a dynamo-electric machine (such as is commonly used in electroplating), is made to pass through this bath, the aforesaid articles being suspended therein, so that they shall form the anode of the circuit, any equivalent metallic surface being introduced at the cathode.

After an immersion in the cyanide bath for a varying length of time, from ten (10) minutes to half an hour, according to the character and quality of the products to be cleansed, the

articles are removed and given a dipping in a bath of chloride of zinc; they are then ready for the coating. For this purpose, they are introduced into a bath of molten lead, previously prepared by the addition of phosphorus and arsenic, as above described, and are kept beneath the surface of the molten metal until a uniform and otherwise satisfactory coating of metal is obtained. This operation will require from five to fifteen minutes. From the metal bath the articles are quenched in a vessel of oil, and finally dried in sawdust.

The essential novelty of this process, in which it differs from current practice, consists in submitting the articles to electrolytic treatment in a solution of cyanide of potassium to insure the more perfect cleansing of their surfaces. The more perfectly this preliminary cleansing, the more uniform and adherent will be the subsequent coating of metal, other things being equal. The extremely effective cleansing action of the cyanide of potassium has long been known and utilized in the art of electro-plating, in which, however, it is employed by simple immersion therein of the article to be cleansed. By Mr. Clamer's procedure, this cleansing action is distinctly reinforced by the aid of the electric current.

As an improvement in the current practice of cleansing metals to receive a deposit of another metal by immersion, as in tinning, galvanizing and leading, the method of Mr. Clamer is worthy of commendation.

The Committee has had the opportunity of witnessing the entire process in operation, and of examining the finished products. The latter, so far as appearances can be relied upon to form a judgment of their quality, were all that could be desired. The coating is smooth, lustrous and adherent both upon cast and wrought iron.

To what extent the quality of the coating may be due to, or influenced by, the presence of the phosphorus and arsenic added to the lead, the Committee is not prepared to express any decided opinion. It is highly probable that these additions may promote the formation of an adherent and smooth coating by their disposition to increase the fluidity of the molten metal. It is well known that it is difficult to secure a satisfactory coating of lead upon iron without notable additions of tin, a much more costly metal. It is probable, therefore, in view of this fact, that the

greater cost involved in the preliminary cleansing operation employed by Mr. Clamer may be offset by the fact that he is able to dispense with the addition of tin to his metal. As to the quality of his product, this is, beyond question, excellent.

The Committee commends Mr. Clamer's inventions as meritorious.

J. H. EASTWICK, WM. H. WAHL,
CHAS. A. RUTTER, S. LLOYD WIEGAND.

Adopted April 4, 1888.

GEO. A. KOENIG, *Chairman.*

I certify the above is a true copy from the records.

WM. H. WAHL, *Secretary.*

BOOK NOTICES

PRACTICAL HINTS FOR DRAUGHTSMEN. By Charles William MacCord, A. M., Sc. D. New York: John Wiley & Sons.

This work is intended to explain practical methods as distinguished from the precise ones of projection, and claims that "*mechanical drawings often convey false impressions by too close adherence to the truth and become obscure by being too exact.*" How well this is illustrated will appear later.

There is originality in the theme, terseness in the language, clearness in the explanations, and a positive, convincing style of expression, well calculated to impress the novice and to start the young B. E. upon methods, many of which would surely lead to mistakes and loss.

Admiring, as we do, the former work of the author and having long recommended it as the best obtainable guide, we trust that the following criticism of this latest production will be carefully considered by him as the conscientious opinion of one who has had long practical experience under favorable and varied conditions, and we hope that, having looked well into the matter of common practice, the author will correct the errors which we feel sure he has been led into, or made inadvertently, and will, with his happy method of expression, give us what is so much needed, a book, correct in detail and embodying the application of principles to actual work.

CHAPTER I contains definitions and rules with illustrative examples. The supposed Code of Laws given in paragraph 7 will not all be admitted as such by any good draughtsman, while the general principles enunciated in paragraph 8 will be accepted as excellent, but an examination of the practical applications of these principles will immediately expose the fallacy of the motive of the chapter. The positive statement that: "*it is amply proved by experience that drawings may be absolutely correct and fail, nevertheless, to show the workman what to make and how to make it,*" is misleading and mischievous, and is unsustained by any of the examples given.

Under Example I, the statement that "*the continuity of masses of metal should not be broken for the purpose of showing fastenings,*" is the key-note of

an erroneous principle which runs through the whole of this chapter, and it would be difficult to compose another sentence so short yet containing so much bad advice. The workman's business is with the fastenings and they are the very things about which he wants definite and clear information. Under the same example, the maxim "*that each view should be made to tell all it can*" (without distortion), "*but nothing should be put in which does not tell something worth knowing*," is excellent, with the above parenthesis inserted, but is violated by *Fig. 1*, which is given to illustrate it. In this figure the top view shows seven bolt holes from which the bolts have been properly omitted, while the vertical section does not tell positively that one bolt is in the central plane, and does show another bolt out of its position, which is not worth knowing.

In Example II the general rule that "*a web parallel to the paper should not be shown in section*," should be taken *cum grano salis*; that is to say, the rule should be the opposite, but occasional exceptions permitted when dictated by very good judgment. *Fig. 3*, given to illustrate the merits of this rule, is the first of a series of incorrect drawings, the only results of which would be doubt, uncertainty and perhaps mistakes.

The so-called maxim in Example IV, that "*if a thing be symmetrical, it should be represented as symmetrical in every view if possible*," is erroneous, because the details which are odd or out of symmetry are the very ones worth knowing and about which the information should be clear and definite. In *Fig. 5* the section through the pulley should stop at the key, thus bringing the latter into prominence and emphasizing the fact that the pulley is to be keyed to the shaft. If the key was headless and the length of the hub (the usual practice) the greater clearness of correct drawing would be more apparent.

In Example VI, the rule "*the fillet lines should be drawn in outside views of surfaces of revolution*," is a bad one, illustrated by numerous examples of faulty drawing, the worst of which is *Fig. 10*, in which the joint between a collar pinned on a shaft and a rotating piece on the same shaft happens to coincide with the fillet line, necessitating the objectionable practice of sectioning over an outside view, in order to prevent the two pieces from being mistaken for one. This practice is actually recommended in Example VIII, and illustrated by *Fig. 9*, which would better serve as a warning for its avoidance.

There is, in Example VII, an adage which can be heartily recommended, viz: "*Judicious omission is preferable to correct superfluity*." Unfortunately, *Fig. 8* does not illustrate this with any force, insomuch as there is no gain in omitting the cap from the *plan*. In this figure the *plan* is placed *under* the elevation, while in other figures it is placed *above*, showing no positive system. Although the use of the third angle in making projections is far more sensible, convenient and clear than the first, still there is no vital objection to the use of the first if it is in all cases strictly adhered to, but a mixture of the two is sure to lead to mistakes in the shop.

Inasmuch as we have been in the habit of quoting the author as one who has advocated strongly the "common sense method of drawing" in which the third angle is used, we feel disappointed to note the disregard of this in many of his examples.

There is no merit whatever in the point made in Example X that, "*thus the true dimensions are seen in both views*," which is illustrated by *Fig. 11*.

On the contrary, if the drawing was complicated and not merely the simple detail which it is, the suggested variation from the truth would be extremely confusing, and, in the present instance, it does far more harm than good.

The most inexcusable case of bad drawing is in Example XII, *Fig. 13*. The impression given by the section is that the gland is held by four stud-bolts, and this we have verified by submitting the drawing, with the top view concealed, to several pattern-makers and experts. When, however, the top view is seen, the mind is in doubt as to what is meant by such a distortion for no useful purpose. A pattern-maker would waste much time in worry and inquiry before commencing work from such a drawing.

Without going further into an analysis of the details of this chapter, we feel convinced that, if an establishment employing a large number of draughtsmen should permit each individual to devise inaccurate and inexact methods of drawing, based upon the hints given in this chapter, trouble, loss of time and confusion would result. And besides, we feel constrained to say that, looked at from our standpoint, each deviation from accurate methods or well-established conventionalities has diminished both the clearness and force instead of increasing them.

Chapter II, on the REPRESENTATION OF BOLTS, ETC., is, in many respects, as erroneous as the preceding. Good taste and sound judgment dictate that the outside face of nuts should be chamfered, both for the sake of appearance and to prevent the edges from becoming battered up by the use of the wrench. There is no necessity to chamfer the bearing face also, because all bolt holes should be faced. In cases where the surface, against which the nut bears, is polished, it is the custom of some shops to turn off an additional shaving (say one hundredth of an inch) from the corners parallel with the face, to prevent the risk of these corners marking the polished surface. This is good practice and is cheaply done. Jamb nuts only are chamfered on both faces in order to protect their edges.

It is a mistake to make a different standard for the sizes of bolt heads from that for nuts, because both through bolts and tap bolts are frequently used in the same piece and on the same surface, where appearance, convenience and every consideration would require that the bolt heads and nuts should be of the same size.

Chapter III, on FREE-HAND SKETCHING, is the best portion of the book.

Chapter IV, on INSTRUMENTS, in many particulars shows want of familiarity with good practice. The implied disparagement of the Alteneder instruments is unjust, particularly as every piece that Alteneder makes is the superior of those described in the book. The old triangular scale, with twelve different scales on one piece of boxwood and with the subdivisions into inches and fractions made only in the first foot or unit of each, is minutely described and elaborated. This is the scale which every apprentice starts out with and abandons as soon as he gets down to real business. Still, on the whole, this chapter gives information, much of which is useful, on points which are not to be found in print.

Taking the book as a whole, its literary merits, ingenious arguments and epigrammatic assertions should not be permitted to cause its acceptance as an authoritative guide. W. H. THORNE.

COLLECTION DES ANCIENS ALCHIMISTES GRECS.—Par M. Berthelot, Membre de l'Institut, avec la Collaboration de M. Ch. Em. Ruelle. Première Livraison. xxiv, 268 et 115 pp. 4to. Paris. Gouvernement, 1888.

This first part of a publication, whose contemplated length is extended, includes an introduction by M. Berthelot, a Greek text with variations and philological notes by M. Ruelle, Librarian of the Bibliotheque St. Geneviève of Paris, a translation of the same by the two authors, and with notes and comments by M. Berthelot. It is an exhaustive study of Greek manuscripts belonging to Leiden and to Venice, the latter having been loaned to M. Berthelot two years by the Italian government. The Greek text was copied by M. Ruelle from MS. 299 of St. Mark's Library, dating back to the tenth century, No. 2,327 of the Bibliotheque Nationale of Paris, which is of the fifteenth century, and twelve later manuscripts. The largest of the latter is No. 2,419, and is written under the name Theoctonicus; it is unquestionably of the same authorship as the later Latin alchemy, attributed to Alberto Magnus.

The introduction of 268 pages opens with a history and description of the Papyrus X of Leiden, the actual date of which is in the third century of our era, but whose contents must have been brought down from a much more remote epoch. It is one of the works of Egyptian alchemy that escaped the general destruction of Eastern literature undertaken by Diocletian toward 290. It proves the Egyptian origin of alchemy and of the ideas of transmutation of metals. These ideas do not appear to have arisen in philosophical dreams, but to have been the outcome of trade tricks of Egyptian goldsmiths.

The Leiden Papyrus, more especially devoted to chemistry, is composed of ten leaves, 0·30 x 0·34 metre, comprising sixteen pages of writing in capital letters of the end of the third century. It bears evidence of being the work-room note-book of a tricky goldsmith and charlatan magician, and was probably preserved in a tomb or mummy of Thebes. By this accident it escaped the Roman destruction and the mutilations of Fellah curiosity merchants. Its great resemblance, almost identity, with later Greek alchemists, shows the sources used by the latter. A Latin translation of this MS. has been published in two 4to volumes by Leemans, of Leiden.

The text is a mixture of astute receipts, charlatanism, gnosticism and Egyptian, Jewish and Pagan mysticism, and indicates that the first notions of alchemy did not originate in chimerical imaginings, but in positive practices and real experiments for the imitation of gold and silver—sometimes purely for the deceit of the public and without self-illusion, sometimes with the addition of magic formulæ and prayers that rendered the author the dupe of his own work.

The recipes include seventy-five formulæ of metallurgy; the composition of alloys for making cups, vases and images; for soldering and artificially coloring the surface of metals, and for testing their purity. These recipes follow one another without order, and with numerous repetitions, as would be the case in the note-book of a goldsmith working sometimes with pure

metals, sometimes with alloys and sometimes with imitations. The text is full of idioms and errors of orthography and grammar; it is the practical language of an artisan, and it bears the stamp of great sincerity, without a shade of charlatanism, notwithstanding the professional dishonesty of the recipes.

These recipes, as well as those of the other MSS. are given and commented on, and the drawings of apparatus and mystic symbols of the St. Mark's MS. are reproduced.

One curious discovery of M. Berthelot is that the accepted etymology of *cobalt* is questionable. It is generally believed that the word is of German origin, referring to the demons which were credited with the difficulties in the working of cobaltiferous ores. Cobalt blue has, however, been found in Greek and Roman antiquities and Egyptian beads, and M. Berthelot calls attention to a passage in the Lexicon Alchemiæ Rulandi, "Cobatiorum fumus est kobolt," and finds the same expression in a passage cited by Olympiodore in his Greek text. There has then been a probable confusion between an ancient Greek word and a German one, notwithstanding that the precise sense of the modern word cobalt is different from that of its progenitor, which referred to a sulphurous arsenical mineral.

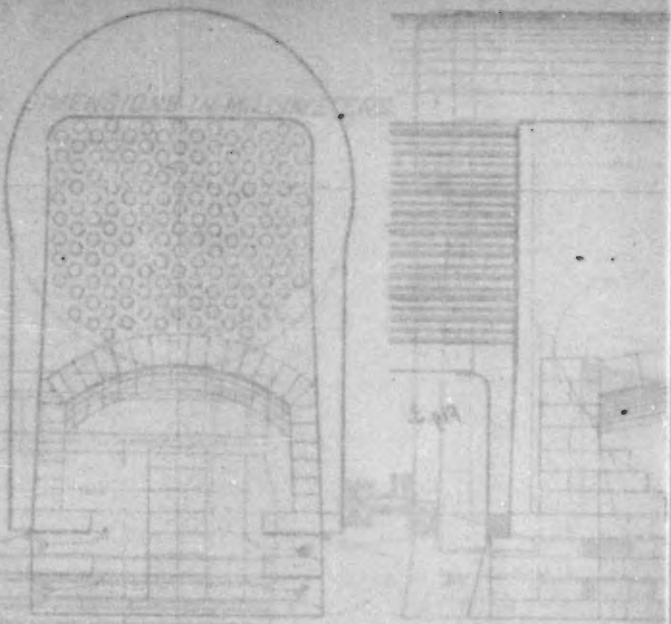
The work is written in M. Berthelot's best style, and will be of great value to those who are interested in the study of the origins of chemistry.

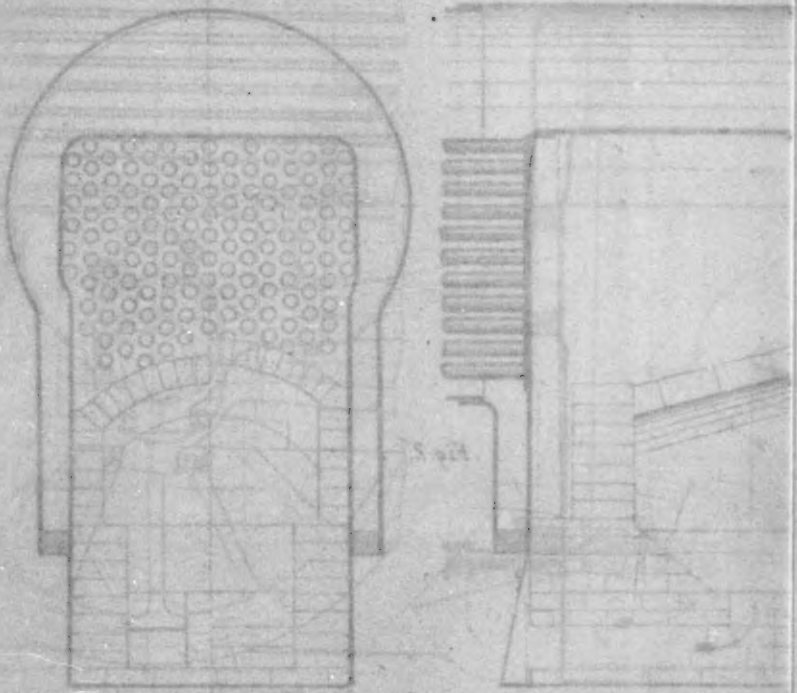
W. H. G.

NOTE TO LIBRARIES AND INDIVIDUALS.—It is not generally known that the International Congress of Geologists invites the membership not only of those individuals who can attend, and of those who cannot attend the sessions next September, but also of *societies*, *libraries* and *institutions*, which of course cannot be looked upon as geologists. The object it has in view is one of equal benefit to the Congress and to the individuals and institutions. The former desires the widest possible circulation of its work, and for a price absurdly disproportionate to the value of the documents received, each subscriber can receive the published proceedings of the Congress containing the latest summaries of the broadest questions by the international and national committees, and a goodly list of special publications prepared by different persons and societies for distribution at the Congress and generally printed in the editions which are regulated by the number of subscriptions to the Congress. These documents embody the latest researches on their various subjects and are not procurable otherwise than by this distribution. Add to this that in the recorded debates and discussions which the proceedings contain, one is made aware of the light in which the best minds view the several subjects treated. The volumes of previous Congresses (Paris and Bologna) are almost out of print and hard to secure at two or three times the cost of "matriculation" or "cotisation" (as the French call it), while the documents which were distributed to the members of those Congresses are unattainable.

If ten shillings be sent to Mr. Wm. Topley, General Secretary of the Committee on Organization of the Congress, Geological Museum, 28 Jermyn Street, London, together with the name of the person or institution desiring to become a subscribing member of the Congress, all these documents will be sent to the said subscriber free.

P. F.





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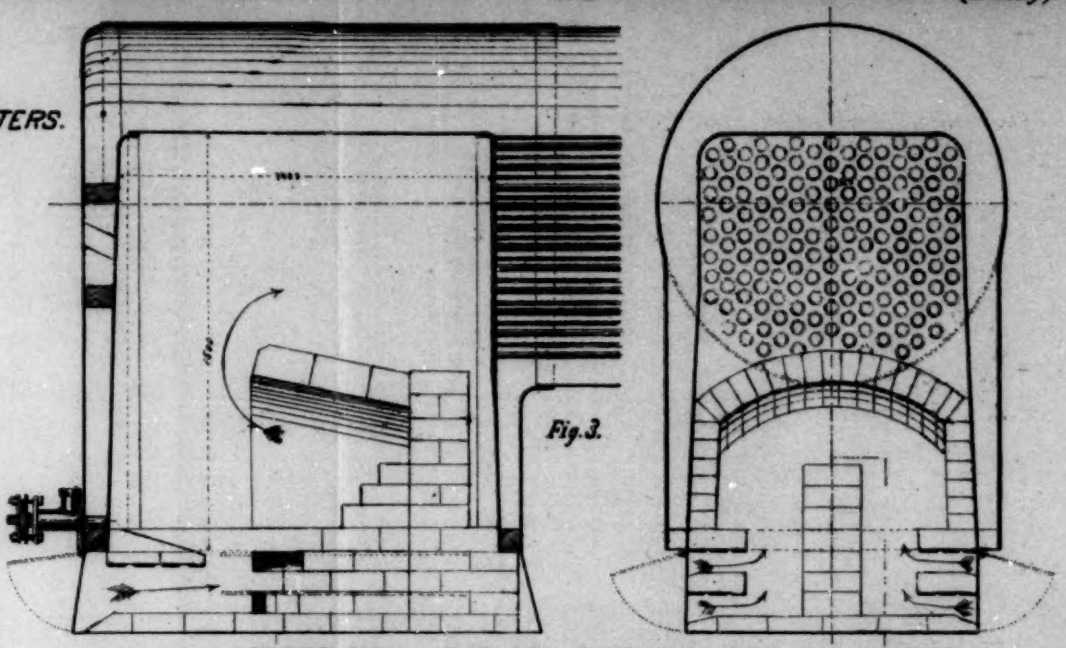


Fig. 3.

PETROLEUM FURNACE - REAR AND SIDE AIR INLETS.

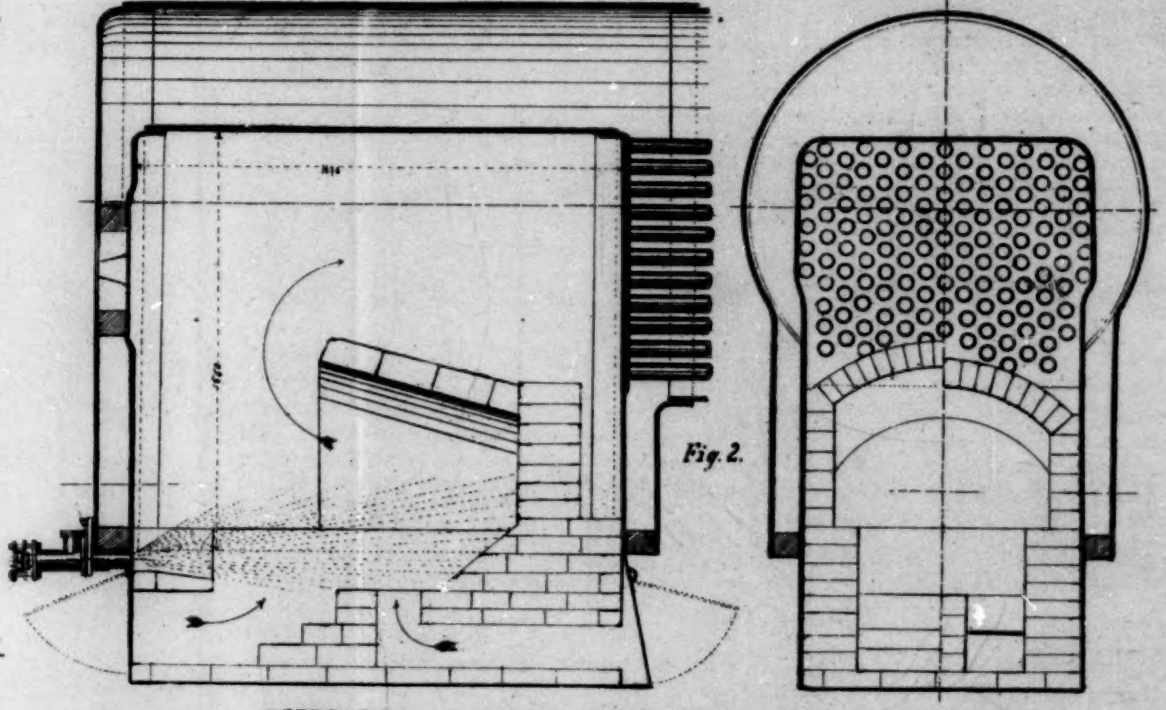


Fig. 2.

PETROLEUM FURNACE - FRONT AND REAR AIR INLETS.

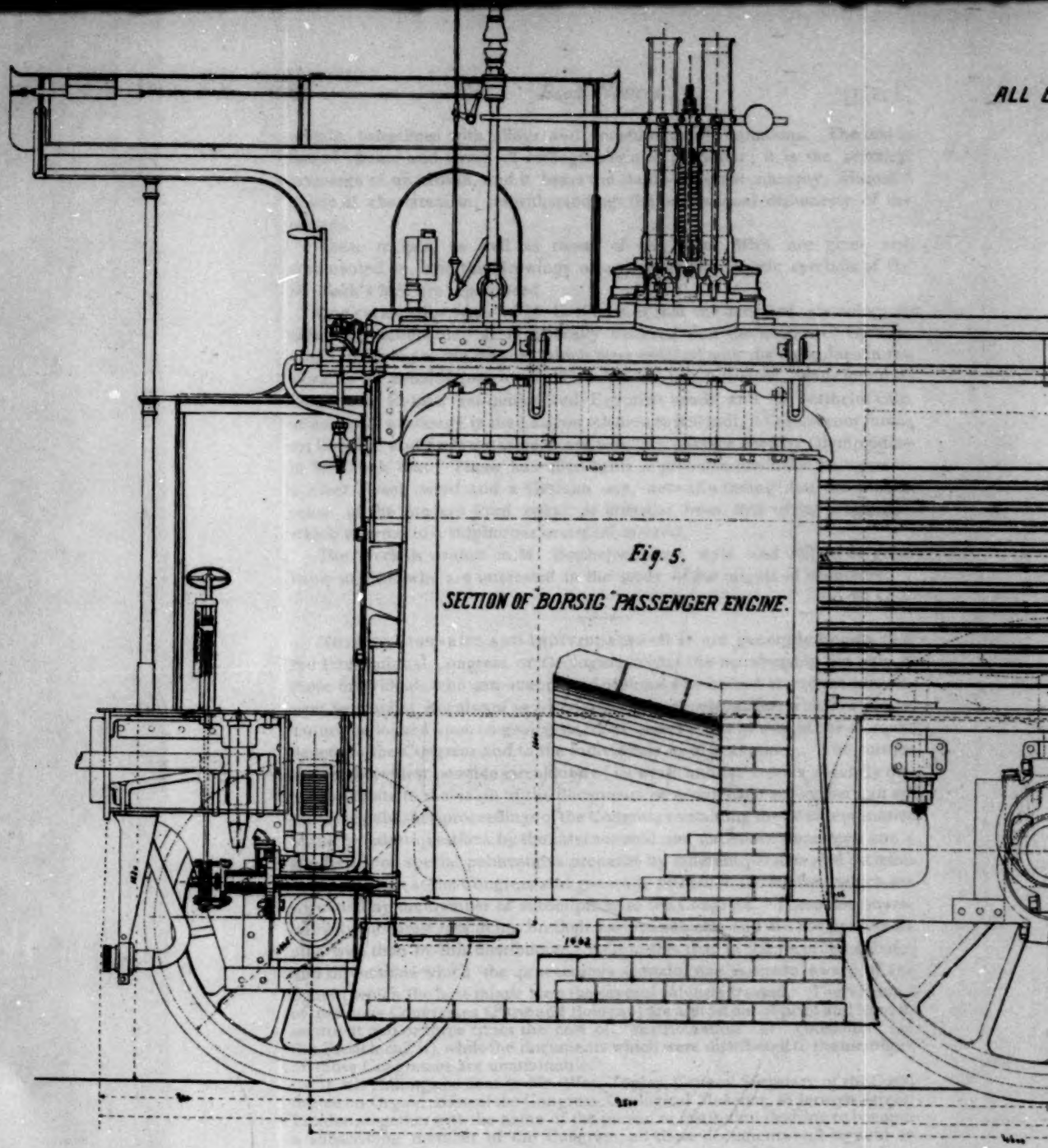
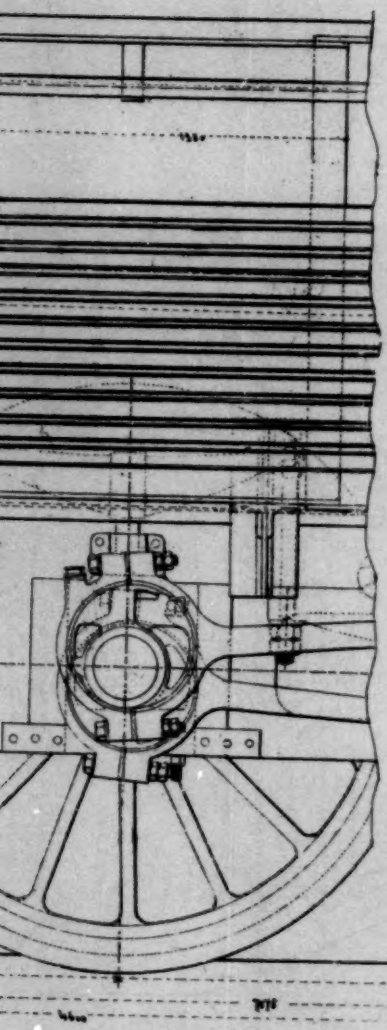
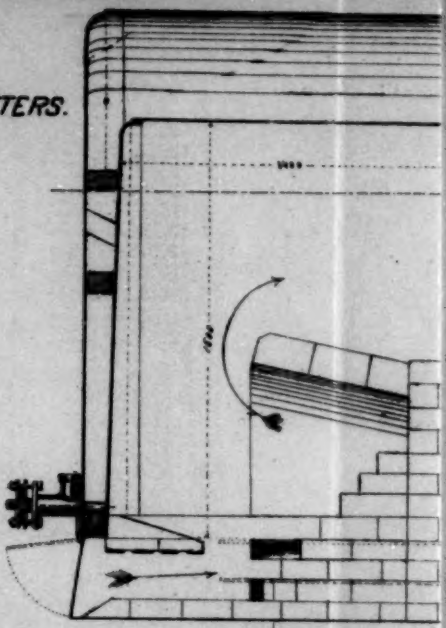


Fig. 5.

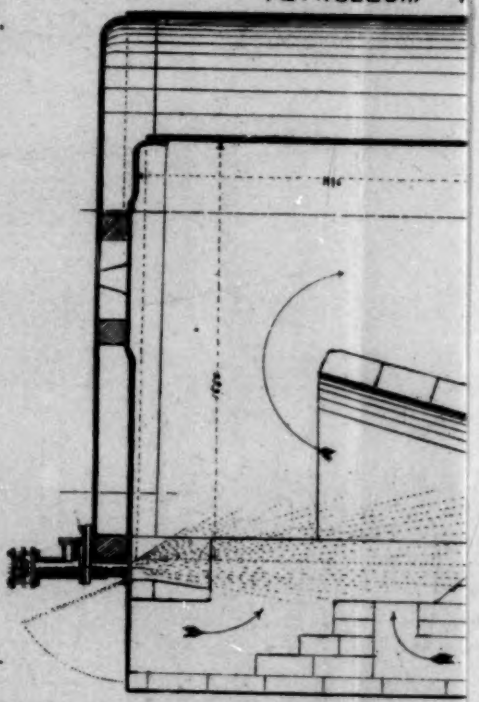
SECTION OF BORSIG PASSENGER ENGINE.

ALL DIMENSIONS IN MILLIMETERS.





PETROLEUM



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